Bellcomm

955 L'Enfant Plaza North, S.W.
Washington, D. C. 20024

date: June 21, 1971

to: Distribution

from: W. W. Ennis

subject: Pre-Landing Adjustments to Landing
Site Position: NOUN 69 in Apollo 15
Case 310

B71 06031

ABSTRACT

The three types of manually-inserted landing
site position adjustments planned for use in Apollo 15
are discussed and explained at a detailed operational
(but not computational) level. Two of the three types
are new and are intended to counter the effects of certain
malfunctions and dispersions that could reduce the proba-
bility of attaining the nominal landing site.

This memorandum consists essentially of the
briefing on this subject given to the Apollo Program
Director on May 19, 1971. Parts of the original presen-
tation have been amplified and clarified, however, and
some corrections have been made to the figures.

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MEMORANDUM FOR FILE

INTRODUCTION

In earlier missions (Apollo 12 and 14) only one
NOUN 69 correction was incorporated. In Apollo 15 there are
three different kinds of NOUN 69, and a possible total of
five corrections. The reason for the proliferation is that
the Apollo 15 site is difficult and NOUN 69 insertion is the
easiest--perhaps the only--way to make last minute navigation
corrections before the LM lands.

NOUN 69 is the Display and Keyboard (DSKY) designation
for a change in landing site position to be entered in the LM
Guidance Computer (LGC). The changes are in the landing site
coordinate frame, i.e., downtrack, crosstrack, and radial; the
units are feet. The quantities to be entered are computed on
the ground, voiced up to the crew, and entered manually by the
crew into the LGC by means of the DSKY.

The three kinds of NOUN 69 in Apollo 15 are:

BACKUP RLS2 (No. 1 on Figure 1), which is loaded
before calling P63 (the braking phase computer program), if
it has not been possible to uplink (automatic loading into
the LGC from the ground) the final adjusted landing site
position or RLS2;

NOMINAL (No. 2 on Figure 1), which is loaded at
Powered Descent Initiation (PDI) plus 2 minutes to correct
for orbit propagation errors in the last pass, down to PDI;
and

NAVIGATION (Nos. 3, 4, and 5 on Figure 1), to
correct for accelerometer biases and certain other errors
that cause position errors to build up after PDI.

1. BKUP RLS2　　　　　　　　　　= V25N69 = 569.　3 COMPONENTS　　　　　　　　　　PDI − 10 MINUTES

2. N69 NOMINAL　　　　　　　　　= V21N69 = 169.　DOWNRANGE (Z) ONLY　　PDI + 2 MINUTES

3. N69 DOWNTRACK NAV　　= V21N69 = 169.　DOWNRANGE (Z) ONLY　　PDI + 5 MINUTES

4. N69 CROSSTRACK NAV　　= V22N69 = 269.　CROSSTRACK (Y) ONLY　　PDI + 5 MINUTES

5. N69 RADIAL NAV　　　　　　= V23N69 = 369.　ALTITUDE (X) ONLY　　　PDI + 8 MINUTES

NO. 2, NOUN 69 NOMINAL, IS THE FAMILIAR NOUN 69 USED IN PREVIOUS MISSIONS. THE
OTHERS ARE ALL NEW FOR APOLLO 15, AND ARE CONTINGENCY PROCEDURES.
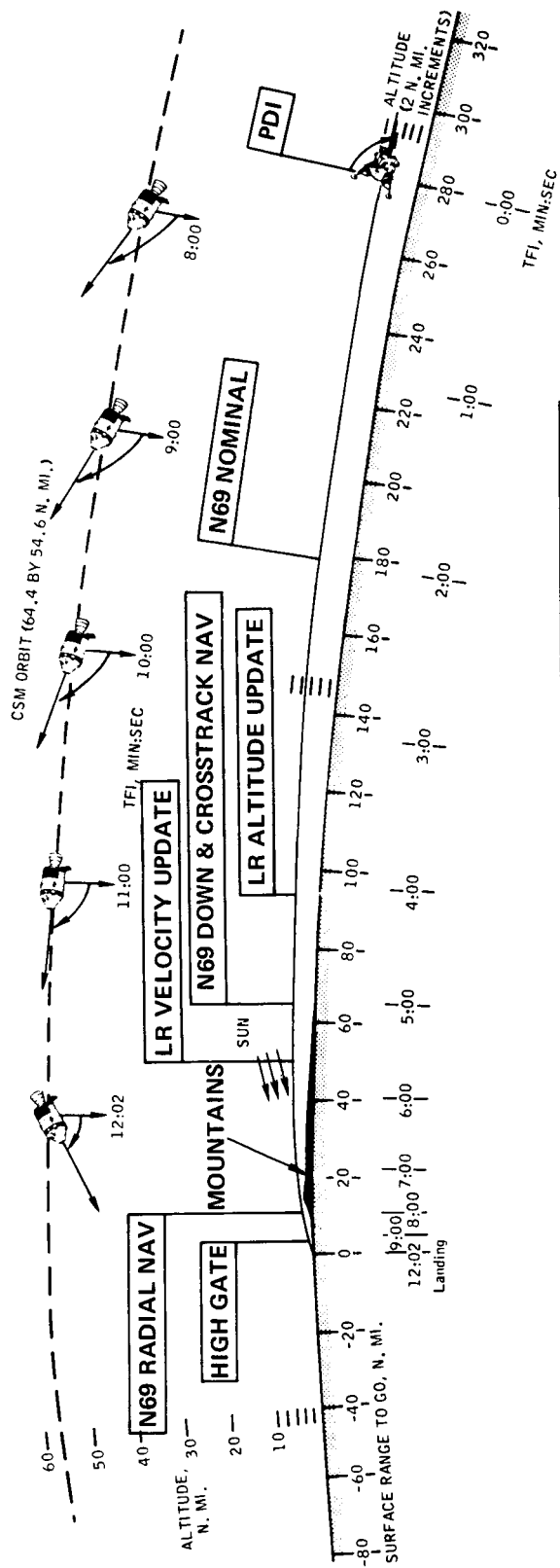
FIGURE 1 - APOLLO 15 NOUNS 69

When a NOUN 69 is to be loaded into the computer, the component being entered is specified by the appropriate verb on the DSKY. VERB 22 (V22), for example, means "Load Component 2", the crosstrack component. The "V2xN69" designations shown on Figure 1 are the DSKY entries for loading the corresponding adjustments; the three-digit designations "569", "169", etc., are a conversational shorthand used by MSC Flight Dynamics people and the Flight Crew to refer to the same entries.

All of the NOUNS 69 except the NOMINAL are contingency procedures: they are required only when certain things do not work quite right. It should be emphasized here, however, that insertion of NOUN 69 corrections does not affect the abort limits. The abort limits are specified maximum-allowable guidance system velocity discrepancies: if any of these is exceeded during powered descent, the descent is aborted. The abort limits are based on the requirement that both the Abort Guidance System (AGS) and PGNCS be available for abort guidance, and establish velocity errors (if and as they develop during powered descent) as criteria of deterioration of a guidance system's capability to control an abort. The NAVIGATION NOUNS 69 can correct <u>position</u> errors resulting from PGNCS velocity errors, but do <u>not</u> affect the velocity errors themselves nor the PGNCS degradations that cause them.

The descent profile (Figure 2) shows where along the descent these various inputs are made. It also shows, in more or less the right size and place, the Apennine Mountains. The CSM track above shows the effect of circularizing one and a half orbits before PDI: The CSM is almost overhead at touchdown.

BACKUP RLS2

A mixed timeline and logic chart (Figure 3) shows the normal sequence of events along the vertical line extending down the middle, and the situation that would lead to use of NOUN 69 to back up the normal RLS2 procedure. It is essential to get landmark tracking data and state vector update data into the LGC to get to the nominal landing site. A new Mission Rule establishes that if we don't get the landing site landmark tracking an alternate landing site (across the Rille, or to the North; not yet decided) allowing larger landing dispersions than the nominal one will be loaded.

N69 RADIAL NAV

HIGH GATE

LR VELOCITY UPDATE

N69 DOWN & CROSSTRACK NAV

LR ALTITUDE UPDATE

N69 NOMINAL

PDI

CSM ORBIT (64.4 BY 54.6 N. MI.)

ALTITUDE (2 N. MI. INCREMENTS)

TFI, MIN:SEC

SURFACE RANGE TO GO, N. MI.

ALTITUDE, N. MI.

SUMMARY					
EVENT	TFI, MIN:SEC	V_I, FPS	$\dot{H}$, FPS	H, FT	ΔV, FPS
POWERED DESCENT INITIATION	0:00	5562	-5	50 087	0
THROTTLE TO MAXIMUM THRUST	0:26	5534	-4	49 979	28
YAW TO VERTICAL	3:00	4111	-58	44 040	1468
LANDING RADAR ALTITUDE UPDATE	4:06	3444	-67	39 878	2159
LANDING RADAR VELOCITY UPDATE	5:34	2500	-85	33 623	3167
THROTTLE RECOVERY	7:24	1163	-80	22 950	4597
HIGH GATE	9:24	318	-162	7 029	5640
LOW GATE	10:42	66 (76)*	-23	694	6241
LANDING	12:02	-15 (0)*	-5	5	6698

* (HORIZONTAL VELOCITY RELATIVE TO SURFACE)

FIGURE 2 - POWERED DESCENT PROFILE

REV | TIME | ACTIVITY

12 | 100:56 | AOS
| 101:05 | UNDOCK
| 101:30 | P24 LANDING SITE LANDMARK TRACKING BY CMP: LOW-ALTITUDE
| 102:04 | LOS
| 102:10 | CSM CIRC
13 | 102:52 | AOS
| 103:30 | P24 LANDING SITE LANDMARK TRACKING BY CMP: HIGH ALTITUDE
| 104:00 | LOS
14 | 104:45 | AOS
| 104:58 (PDI MINUS 10 MINUTES) | SV2 / OR / BACKUP RLS2 NOUN 69 / OR / NO FURTHER PRE-PDI CORRECTIONS
| 105:08 | PDI
| 105:20 | TD

WAS THIS REV 12 LS LMK TRACKING SUCCESSFUL?

NO → CALCULATE RLS1: APPLY TWO REVS OF PROPAGATION OFFSETS TO MAP LS COORDINATES

RLS2 BASED ON REV 13 CSM DETERMINATION OF LS COORDINATES MUST GET INTO LGC IF LANDING IS TO BE AT NOMINAL SITE IN REV 14

YES → CALCULATE RLS1: APPLY TWO REVS OF PROPAGATION OFFSETS TO LS COORDINATES DETERMINED FROM REV 12 TRACKING

CALCULATE MODIFIED RLS2 FOR VOICE TRANSMISSION AS NOUN 69 IN CASE UPLINK OF RLS2 IS UNSUCCESSFUL.
(1) SINCE LM STATE WILL BE PROPAGATED FROM SV1 (TWO REVS) IF UPLINK FAILS, APPLY TWO REVS OF PROPAGATION OFFSETS TO LS COORDINATES DETERMINED FROM REV 13 TRACKING
(2) TRANSFORM FROM LATITUDE, LONGITUDE, AND RADIUS TO DOWNTRACK, CROSSTRACK, AND RADIUS DELTAS (LANDING SITE FRAME)

VOICE UP BACKUP RLS2 NOUN 69

COMMAND (UPLINK) RLS1 AND SV1 FROM GROUND TO LGC

CALCULATE RLS2: APPLY ONE REV OF PROPAGATION OFFSETS TO LS COORDINATES DETERMINED FROM REV 13 TRACKING.

KEEP TRYING WITH THE UPLINK

COMMAND RLS2

SUCCESSFUL?

IS TIME TILL PDI MORE THAN 10 MINUTES?

YES

NO → ABANDON ATTEMPTS TO UPLINK RLS2. SINCE UPLINK OF SV2 WILL PROBABLY ALSO NOT WORK, ABANDON THAT TOO

WAS RLS1 BASED ON GOOD LANDING SITE LANDMARK TRACKING DATA?

NO

YES → GO AHEAD ON RLS1 AND SV1 FOR LANDING AT NOMINAL SITE

COMMAND SV2

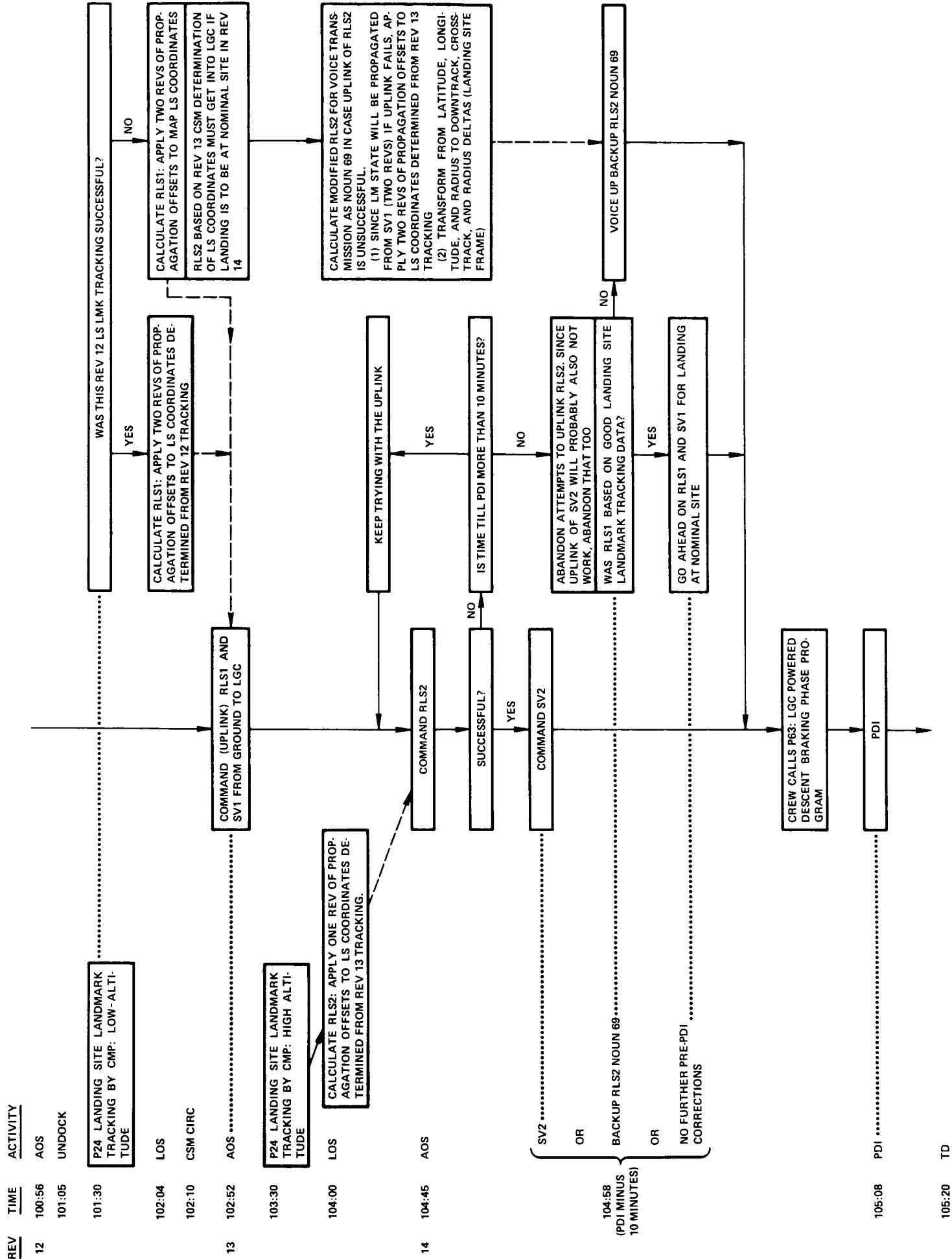CREW CALLS P63: LGC POWERED DESCENT BRAKING PHASE PROGRAM

PDI

FIGURE 3 - BACKUP RLS2 NOUN 69

In Lunar Orbit Revs 2 through 11, the period spent in the descent orbit up to the beginning of the interval shown in Figure 3, a Propagation Offset Study is conducted. This study determines the error arising per orbit, in the vicinity of the PDI point, in the LGC propagation of the LM orbit. This error propagation has been found to be constant or to change very slowly over many orbits, so that it can be used to predict LGC errors on future passes.

The MSFN tracks the spacecraft on each pass across the near side of the Moon, and the RTCC fits orbital solutions to the tracking data. Both single-pass and two-pass fits are generated, and the choice of which to use is based on a real-time comparison of their consistency, the magnitudes of the residuals, etc. The processing of each pass of data is completed after Loss of Signal (LOS) on that pass, so that on each Acquisition of Signal (AOS) there is available a fresh orbital solution (or State Vector, or SV) based on the latest tracking data.

Proceeding now from the top of Figure 3: The MSFN tracks the spacecraft and processes the data as described above. The CSM, now separated from the LM, tracks the landing site landmark (this will likely be "Index" Crater, about 1 km East of the landing site, for Apollo 15). The RTCC also processes the landmark tracking data, and so determines the coordinates of the landmark and thus of the Landing Site in the coordinate system of the Rev 12 orbit. There is thus available to be transmitted to the LM at AOS of Rev 13 a fresh state vector based on Rev 12 MSFN tracking and a tied-in landing site position based on Rev 12 CSM tracking of the landmark. But the propagation errors have to be compensated and, since the landing is not to take place until Rev 14, two revs of propagation errors are involved. The error corrections, or "propagation offsets", are applied to the landing site coordinates rather than to the state vector. It has been found that "adjusting" the state vector is generally undesirable and can lead to poor guidance performance in some abort situations. If, for any reason, the Rev 12 Landmark tracking failed to produce a valid set of landing site coordinates, the propagation offsets are applied to the map coordinates of the landing site Then, after AOS of Rev 13, the new State Vector (SV1) and the adjusted landing site coordinates (RLS1) are commanded (uplinked) into the LM computer.

In Rev 13 the MSFN tracks the LM as before, and the CSM (now in near-circular orbit) again tracks the landing site landmark. The ground computers generate a new orbit solution and another landing site position, based on the Rev 13 data. A "best" landing site position which may be either of the observed positions or some kind of mean of them, is selected after considering such criteria as the internal consistencies of the two sets of marks, the CMP's estimate of his confidence in them, etc. Propagation offsets, for only one rev now, are applied to this landing site position.

At AOS of Rev 14 (nominally the landing pass) the new adjusted landing site coordinates (RLS2) are commanded into the LGC. At PDI - 10 minutes, the new State Vector (SV2) is commanded into the LGC. The crew then calls up P63 at the appropriate time and proceeds with the landing.

It is in this last 10 minutes before PDI that BACKUP RLS2 NOUN 69 may come into use if there has been any difficulty in commanding RLS2 into the LGC. If there is such difficulty, whatever the cause, attempts may be continued until PDI - 10 minutes. If RLS2 has not been commanded into the LGC by that time, it will be assumed that attempts to uplink SV2 would also be unsuccessful. If RLS1 was derived from good landmark tracking, then it and SV1 are satisfactory for going to the nominal landing site and no further efforts need be made with RLS2. But if RLS1 was based on map coordinates, RLS2 is the last chance to get acceptable coordinates for the nominal landing site into the LGC, for landing on this pass. It is then voiced up to the crew for manual entry in the LGC as a three-coordinate NOUN 69. The RLS2 must be modified in two ways for this use. First, since it is to be used with SV1, which will be two orbits old at PDI, propagation offsets for two orbits must be applied. Second, it has to be transformed: From latitude, longitude, and radius to downtrack, crosstrack, and radial corrections to the landing site position.

If landmark tracking was not successful in either Rev 12 or Rev 13, the landing may be deferred one rev and another attempt made to locate the landing site in Rev 14. There would then be an RLS3 and SV3 after AOS of Rev 15, with the same logic applying for a BACKUP RLS3 NOUN 69.

NOUN 69 NOMINAL

It has been found that despite all the propagation corrections and state vector updates, the PGNCS will still have significant downtrack propagation errors in its state

vector as it comes up on PDI. The simplified diagram (Figure 4)
illustrates the principle used in measuring this error. The
MSFN is somewhere in a generally "up" direction from this chart.
The downtrack error is determined by measuring the difference
between the LGC velocity vector and the MSFN-determined velocity
vector. In the drawing the LGC has propagated itself farther
around the orbit than the LM has really gone. While the flight
path angle will in general not be zero as it is shown here, the
difference in flight path angle at the two points is negligible
and the principle is unaltered. The two points have been less
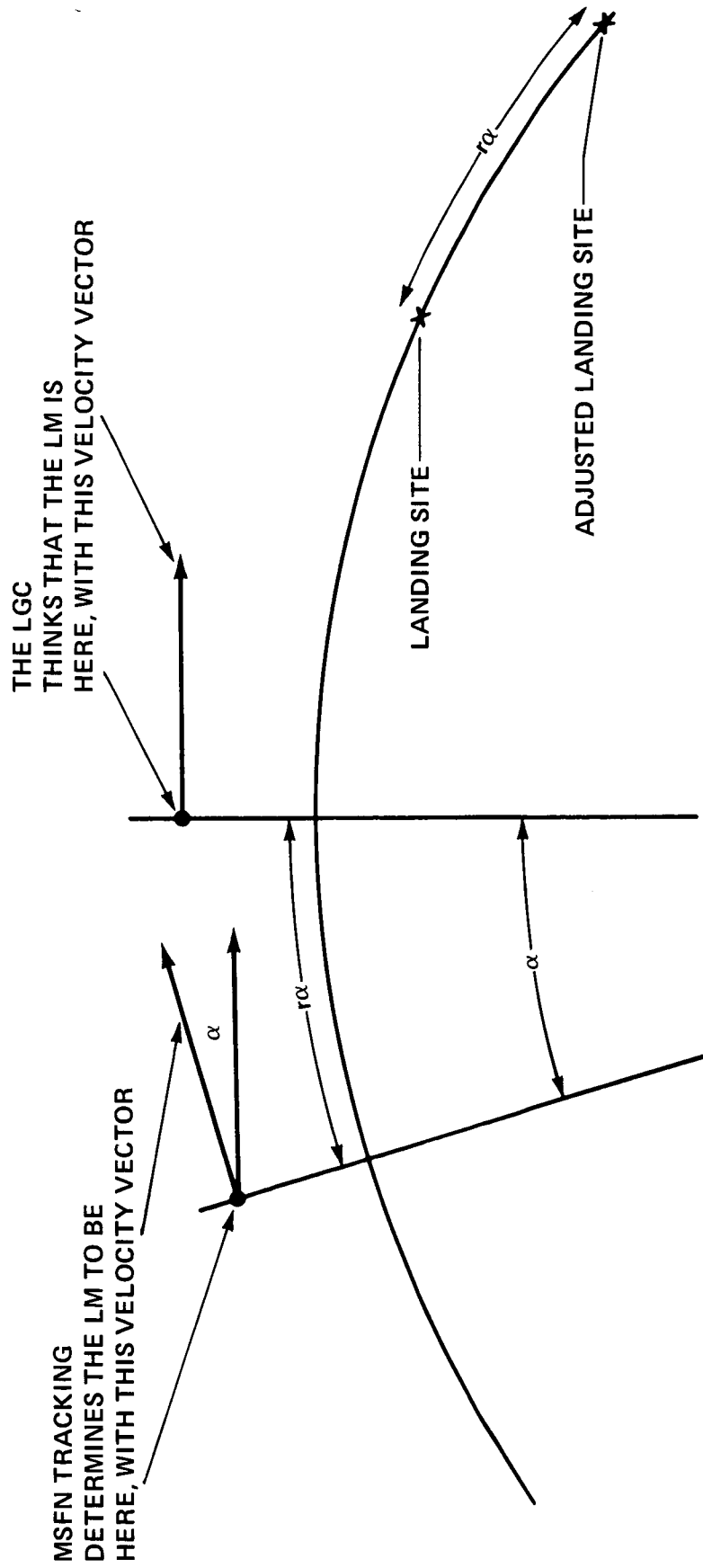than one mile apart in previous missions.

NOUN 69 NOMINAL COMPUTATION

There are three ways of measuring the angular position
error (Figure 5). Two of them use velocity differences, while
the third depends upon range measurement. The preferred method
is based on direct measurement of the line-of-sight velocity
component and is referred to as the "range-rate residual" method.
("Residual" in these applications generally means a delta between
a PGNCS and a MSFN-RTCC value or between a local and a propagated
value, rather than between one of a set of measurements and the
least-squares massaged result of the set of measurements.) This
calculation is done automatically in the Range Rate Residual
Processor (RRRP). The second technique employs the Powered
Flight Processor (PFP, usually called "the LEAR"), which also
now processes the data automatically. The PFP gives as accurate
and reliable results as the RRRP in most cases, but the RRRP is
preferred because it is somewhat more flexible in off-nominal
situations. The third method, using the range residual, tends
to be more noisy and less accurate than the other two. It gives
a reasonable and usable result, however, and remains available.

The error is determined 10 times in the 5 minutes
immediately preceding PDI by both velocity-difference methods.
This makes any irregularity or noisiness or trend pretty
conspicuous and easy to detect.

DOWNTRACK AND CROSSTRACK NAV NOUN 69

Even with perfect landmark tracking, propagation
offsets, and updates we can get into trouble with errors that
build up after PDI (Figure 6). Errors that are well within
the abort limits and would have caused no real concern in
earlier missions are operationally unacceptable in Apollo 15
because of the terrain. The principal source is constant
errors or "biases" in the accelerometers in the IMU in the LM.
The accelerometers feel nothing and output nothing until PDI,
after which they sense the thrust of the DPS. Inertial plat-
form misalignment will cause the three components of the

THE LGC
THINKS THAT THE LM IS
HERE, WITH THIS VELOCITY VECTOR

MSFN TRACKING
DETERMINES THE LM TO BE
HERE, WITH THIS VELOCITY VECTOR

LANDING SITE

ADJUSTED LANDING SITE

THE ANGLE α BETWEEN THE VELOCITY VECTORS IS THE ANGULAR ERROR IN THE LGC LM POSITION. THE DOWNTRACK DISTANCE ERROR IS THEN $r\alpha$. THIS QUANTITY IS EVALUATED BEFORE PDI, VOICED UP TO THE LM AT PDI + 1 MINUTE, AND ENTERED MANUALLY IN THE LGC AT ABOUT PDI + 2 MINUTES.

THE ERROR IS MEASURED IN REAL TIME BY THREE METHODS.

FIGURE 4 - NOUN 69 NOMINAL

IN ORDER OF PREFERENCE:

METHOD 1.   THE LINE-OF-SIGHT RANGE RATE IS DETERMINED BY DOPPLER MEASUREMENT.
THE DIFFERENCE BETWEEN THIS AND THE RANGE RATE DERIVED FROM THE
PGNS VELOCITY VECTOR, CORRECTED FOR THE ANGLE BETWEEN THE VELOCITY
VECTOR AND THE LINE OF SIGHT, GIVES THE ANGULAR ERROR α.

METHOD 2.   THE LEAR PFP DETERMINES THE TRUE VELOCITY VECTOR AND THE VECTOR
DIFFERENCE BETWEEN THIS AND THE TELEMETERED PGNS VELOCITY VECTOR.

METHOD 3.   THE ANGLE α IS DETERMINED FROM THE DIFFERENCE BETWEEN THE MEASURED
RANGE AND RANGE DERIVED FROM THE PGNS POSITION VECTOR. THIS METHOD
IS NO LONGER USED, BUT IS AVAILABLE.

THE ERROR IS DETERMINED EVERY HALF MINUTE FOR THE FIVE MINUTES BEFORE PDI.   EACH
SET OF 10 IS CHECKED FOR CONSISTENCY AND AVERAGED. THE "BEST", I. E., "MOST PREFERABLE"
CONSISTENT AND REASONABLE VALUE IS USED.

FIGURE 5 - NOUN 69 NOMINAL COMPUTATION

- BECAUSE OF THE APENNINE FRONT, DISPERSIONS THAT WERE ACCEPTABLE ARE NO LONGER SO

  EXAMPLE: A CROSSTRACK VELOCITY ERROR OF 30 FT/SEC, WELL WITHIN THE ABORT LIMIT, BUILDS UP A CROSSTRACK POSITION ERROR OF 12000 FEET IN LESS THAN 7 MINUTES.

- CROSSTRACK VELOCITY ERRORS ARE INTRODUCED, BEGINNING AT PDI, BY ACCELER-OMETER BIAS AND BY PLATFORM MISALIGNMENT. DOWNTRACK ERRORS RESULT FROM ACCELEROMETER BIAS.

- WE MEASURE THE DIFFERENCE ("RESIDUAL") BETWEEN VELOCITY AS TELEMETERED BY THE PGNS AND AS DETERMINED BY MSFN, STARTING AT PDI

- FROM THE RESIDUALS — CROSSTRACK AND DOWNTRACK — WE ESTIMATE POSITION ERRORS WHICH WE COMPENSATE BY APPLYING THEM WITH SIGNS REVERSED TO THE LANDING SITE POSITION.

FIGURE 6 - NOUN 69 DOWNTRACK AND CROSSTRACK NAV

thrust to be sensed inaccurately and hence will introduce
false components normal to the true thrust; a misalignment
thus has the same effect as radial and crosstrack accelerometer
errors.

These errors do not exist until powered flight
begins. If they are to be corrected, therefore, they have
to be measured in powered flight; i.e., beginning at PDI.

DOWNTRACK AND CROSSTRACK NAV NOUN 69 COMPUTATION

A pre-mission prepared plot is used. Downtrack and
crosstrack velocity residuals are monitored and measured at
several integral-half-minute intervals after PDI. The plot
is entered with a velocity residual and the time at which it
was observed, and the desired NOUN 69 is read directly
(Figures 7 and 8). The same plot is used for downtrack and
crosstrack corrections. It gives a correction for the error
propagated forward to about PDI plus 8.6 minutes, the time at
which Landing Radar velocity convergence is nominally expected.

The CROSSTRACK NAV NOUN 69 was invented first, to
protect against the Apennine Front on Apollo 15. It was then
decided it could be done downrange too to correct for accel-
erometer errors in that direction, to try to keep the LGC
terrain model synchronized with the terrain.

Both of these corrections go into the LGC at PDI
plus 5 minutes. Both have a threshold value of 3000 feet:
i.e., if the correction is less than 3000 feet, it is ignored.

RADIAL NAV NOUN 69

Three elements enter into the development of radial
(altitude) errors during powered descent (Figure 9). The
first is the difference between the LGC and the real velocity
vectors, the same "residual" that allowed us to calculate the
NOUN 69 NOMINAL so easily. This vector difference is an
essentially radial velocity, and is thus equivalent to an
altitude rate error in the LGC. In principle, putting in the
NOUN 69 NOMINAL removes this error: It is easy to verify on
Figure 4 that the flight path from the imaginary LGC LM posi-
tion to the imaginary (adjusted downtrack by the NOUN 69) LGC
landing site is identical to that from the true LM position
to the true landing site, merely rotated through the angle "α".
In practice, the entering of a NOUN 69 NOMINAL does not cancel
this radial velocity difference as a source of altitude error
during powered descent. NOUN 69 NOMINAL is not entered until
PDI plus 2 minutes; this alters the shape of the trajectory

- THE NOUN 69 IS PLOTTED AS A FUNCTION OF THE VELOCITY RESIDUAL FOR VARIOUS TIMES OF MEASUREMENT OF THE RESIDUAL (TFI = TIME FROM IGNITION).

  THE PLOT ASSUMES

  - LINEAR GROWTH OF VELOCITY ERROR

  - LANDING RADAR VELOCITY DATA COMES IN AT THE NOMINAL 5.6 MINUTES

  - LANDING RADAR VELOCITY DATA CONVERGED BY THE NOMINAL 8.6 MINUTES

  AND GIVES THE ERROR PROPAGATED FORWARD TO PDI + 8.6 MINUTES.

- IT IS READ TWICE FOR CONFIDENCE

- AND PUT INTO THE LGC AT PDI + 5 MINUTES (BOTH CROSSTRACK AND DOWNTRACK)

- THE THRESHOLD IS 3000 FEET IN BOTH COMPONENTS

FIGURE 7 - NOUN 69 DOWNTRACK AND CROSSTRACK NAV COMPUTATION

FIGURE 8 - NOUN 69 FOR PIPA BIAS

ACTUAL LM VELOCITY VECTOR

LGC VELOCITY VECTOR
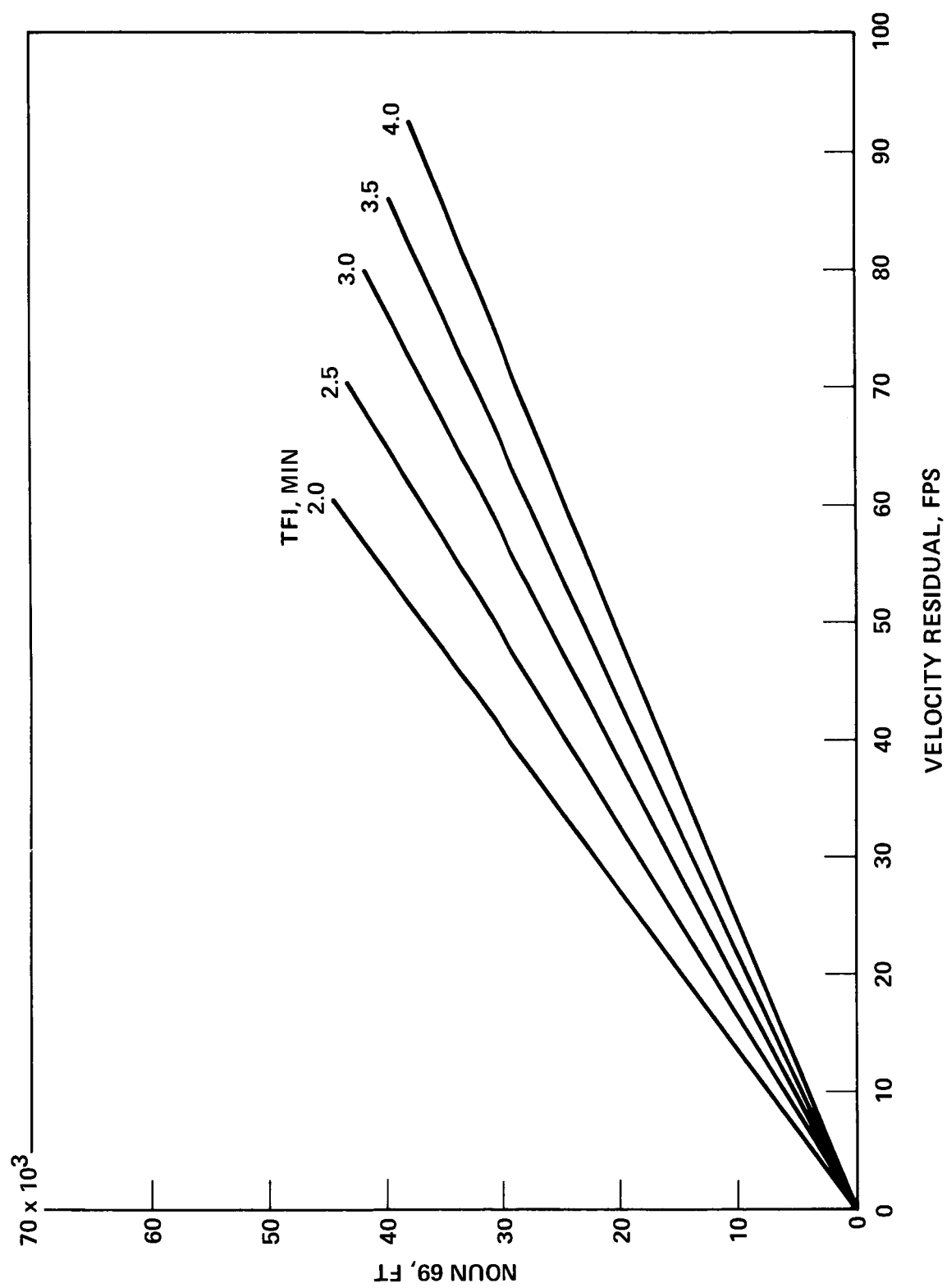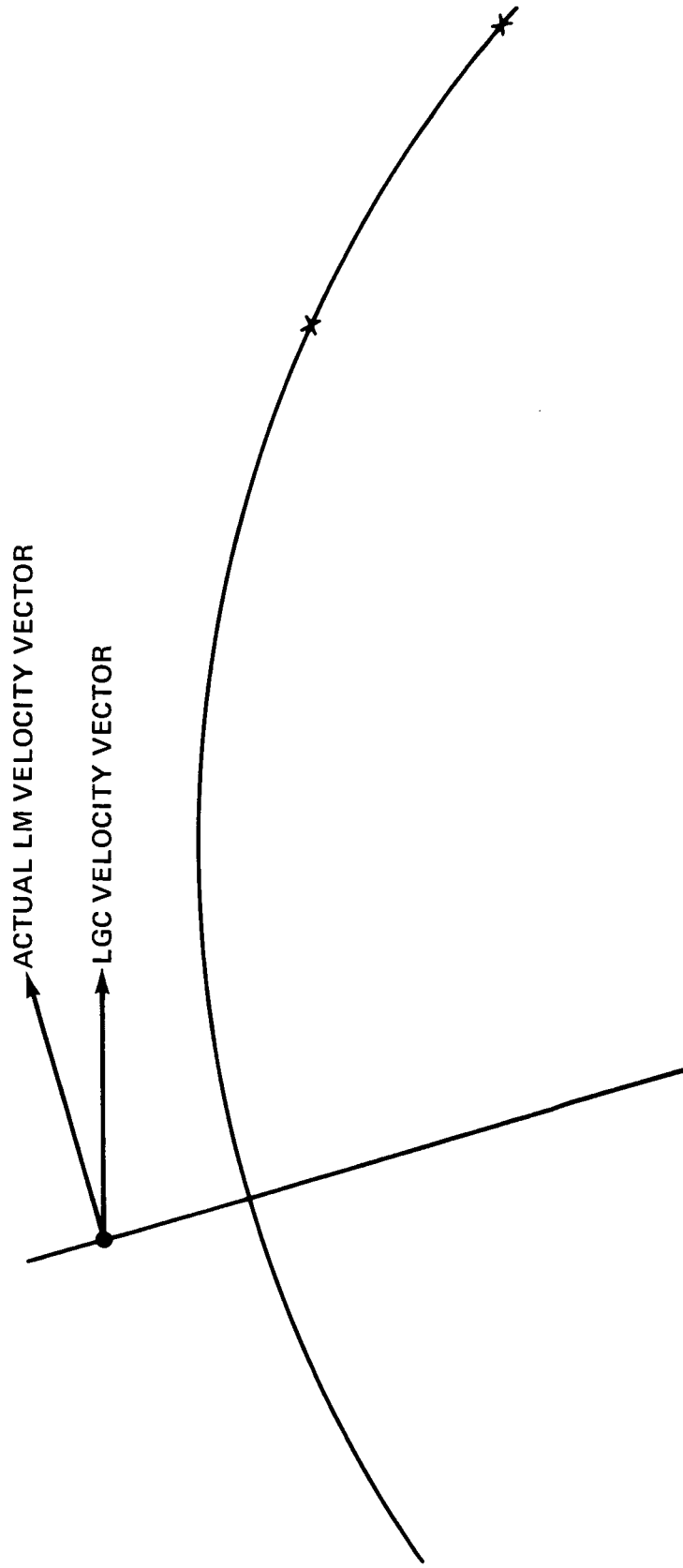
- THE DIFFERENCE BETWEEN THE ACTUAL AND LGC VELOCITY VECTORS IS MOSTLY RADIAL AND THUS CONSTITUTES AN ALTITUDE RATE ERROR. IT EXISTS AT PDI AND REMAINS CONSTANT

- A RADIAL ACCELEROMETER BIAS INTRODUCES AN ALTITUDE RATE ERROR THAT GROWS AT A CONSTANT RATE, STARTING FROM 0 AT PDI

- IN-PLANE PLATFORM MISALIGNMENT HAS THE SAME EFFECT AS ACCELEROMETER BIAS

FIGURE 9 - NOUN 69 RADIAL NAV

and affects the time of throttle recovery. Furthermore, our immediate concern is not with errors the LGC might have after flying uncorrected all the way to touchdown. The RADIAL NAV NOUN 69 is intended to correct certain predictable altitude errors at an intermediate point (currently 6000 feet) in order to allow the LM to fly safely at least that far without landing radar data if the landing radar should be slow in coming in. A look at the descent profile (Figure 2) shows that for a normal NOUN 69 NOMINAL we are talking about a shift of a few thousand feet from one end to the other of a 280 mile long flight path. The altitude rate error is about 1 ft/sec per 1000 feet of NOUN 69 NOMINAL.

Accelerometer bias and platform misalignment introduce a growing velocity error, as in the crosstrack and downtrack directions.

RADIAL NAV NOUN 69 COMPUTATION

The altitude rate error (residual) existing at PDI is known. After PDI, the altitude rate residual is monitored on the ground and recorded at several integral minute points (Figure 10). The nomograph (Figure 11) is entered with the error existing at PDI on the left scale, and with the error existing at a later instant on the center scale corresponding to the time at which it was observed. A line connecting these points, projected across to the right scale, cuts that scale at the required value of NOUN 69. The sample line shown on Figure 11 represents the computation for a radial residual of -5 ft/sec existing at PDI (left scale), which has grown to -10 ft/sec at PDI plus 6 minutes (6:00 center scale); the NOUN 69 is +4000 feet. It should be emphasized that although this is an altitude correction, it is not derived from measurements of altitude. It is a predicted altitude discrepancy calculated from timed measurements of altitude rate error.

It should also again be emphasized that the RADIAL NAV NOUN 69 is not calculated to permit the LM to fly down to the landing site and land without any additional information. The number given by the nomograph is designed to result in a zero altitude error in the LGC at 6000 feet (referred to the landing site radial position as determined by the CSM landmark tracking). The purpose is that the LM may safely go to that altitude as indicated by the PGNCS without landing radar data, in order to give a poorly-performing landing radar every

- ALTITUDE RATE ERROR AT PDI IS KNOWN

- ALTITUDE RATE ERROR IS MEASURED AT PDI + 3, 4, 5, 6, 7, & 8 MINUTES

- ENTER THE NOMOGRAPH WITH THESE NUMBERS TO GET NOUN 69 LANDING SITE RADIUS ADJUSTMENT.

THE NOMOGRAPH ASSUMES LINEAR ALTITUDE RATE ERROR GROWTH AND ITS N69 IS CALCULATED TO GIVE ZERO PGNS ALTITUDE ERROR AT 6000 FT (JUST AFTER LR ANTENNA POSITION SHIFT).

THE RADIAL N69 IS PUT IN AT PDI + 8 MINUTES TO GIVE THE LR EVERY CHANCE TO COME IN, AND IS PUT IN ONLY IF WE ARE FAIRLY CERTAIN WE WILL NOT HAVE LR DATA BEFORE HIGH GATE.

IF THE LR COMES IN AFTER THIS N69 BUT BEFORE 6000 FEET, A Δh WILL BE INTRODUCED. THIS WILL BE CONVERGED LIKE ANY NORMAL Δh.

FIGURE 10 - NOUN 69 RADIAL NAV COMPUTATION
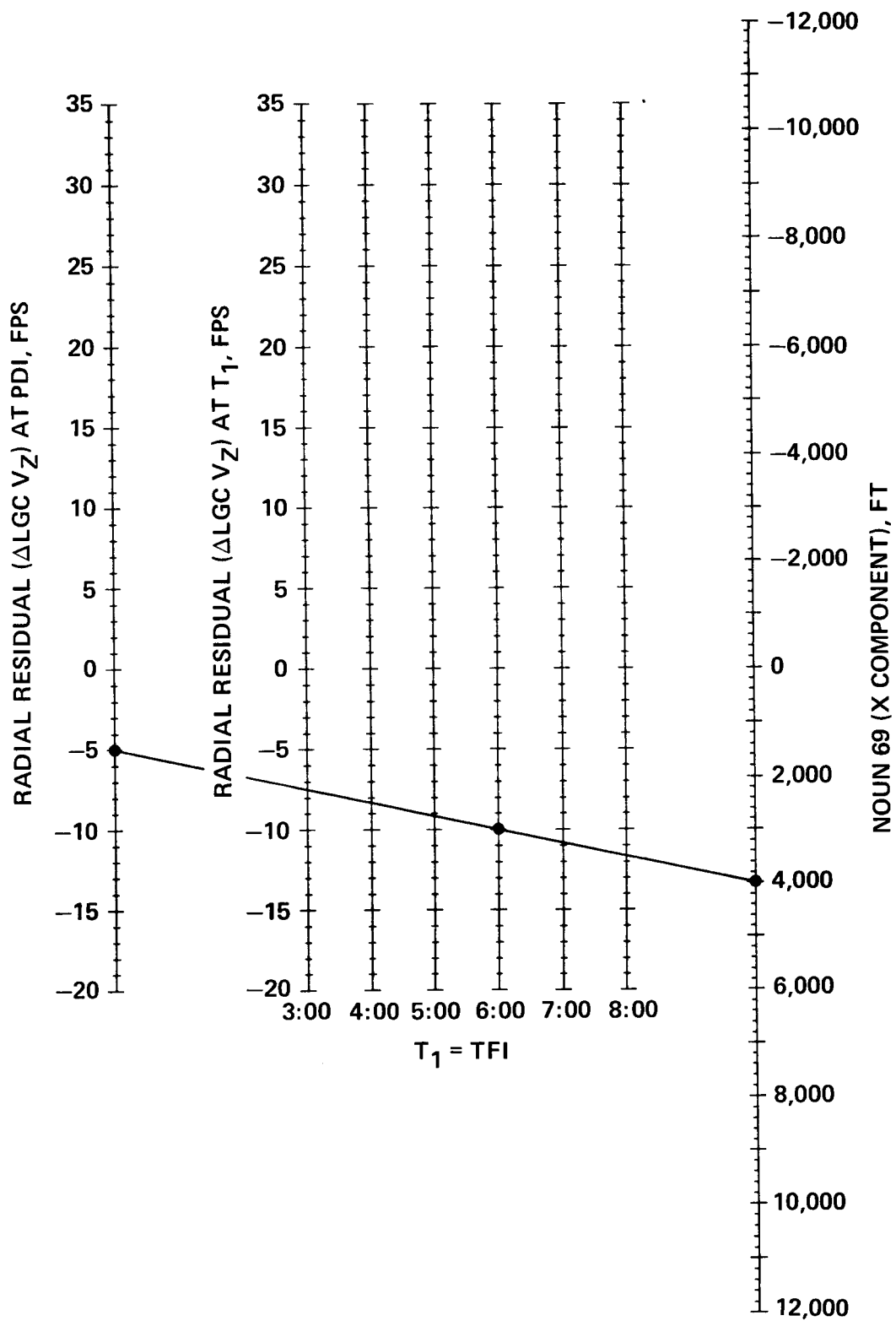
FIGURE 11 - NOMOGRAPH FOR DETERMINING NOUN 69 ALTITUDE CORRECTIONS
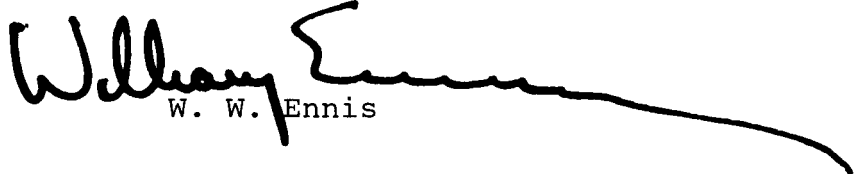
possible chance to come in. If the landing radar has not
come in by 6000 feet, the descent must be aborted. In the
absence of landing radar data and without a RADIAL NAV NOUN
69, the abort limit is 10,000 feet, because of the greater
altitude uncertainty.

The threshold value of RADIAL NAV NOUN 69 is 500
feet. As before, several readings are made for consistency.

2013-WWE-pjr

W. W. Ennis

Subject: Pre-Landing Adjustments to Landing
Site Position: NOUN 69 in Apollo 15

From: W. W. Ennis

FIGURE 3-141: MISSION DEPENDENT RESUPPLY VOLUME - OLSF MODE
(TOTAL MISSION TIME)

FIGURE 3-142: TOTAL RESUPPLY REQUIREMENT - CLSF MODE (WEIGHT)

FIGURE 3-143: TOTAL RESUPPLY REQUIREMENT - OLSF MODE
(VOLUME)
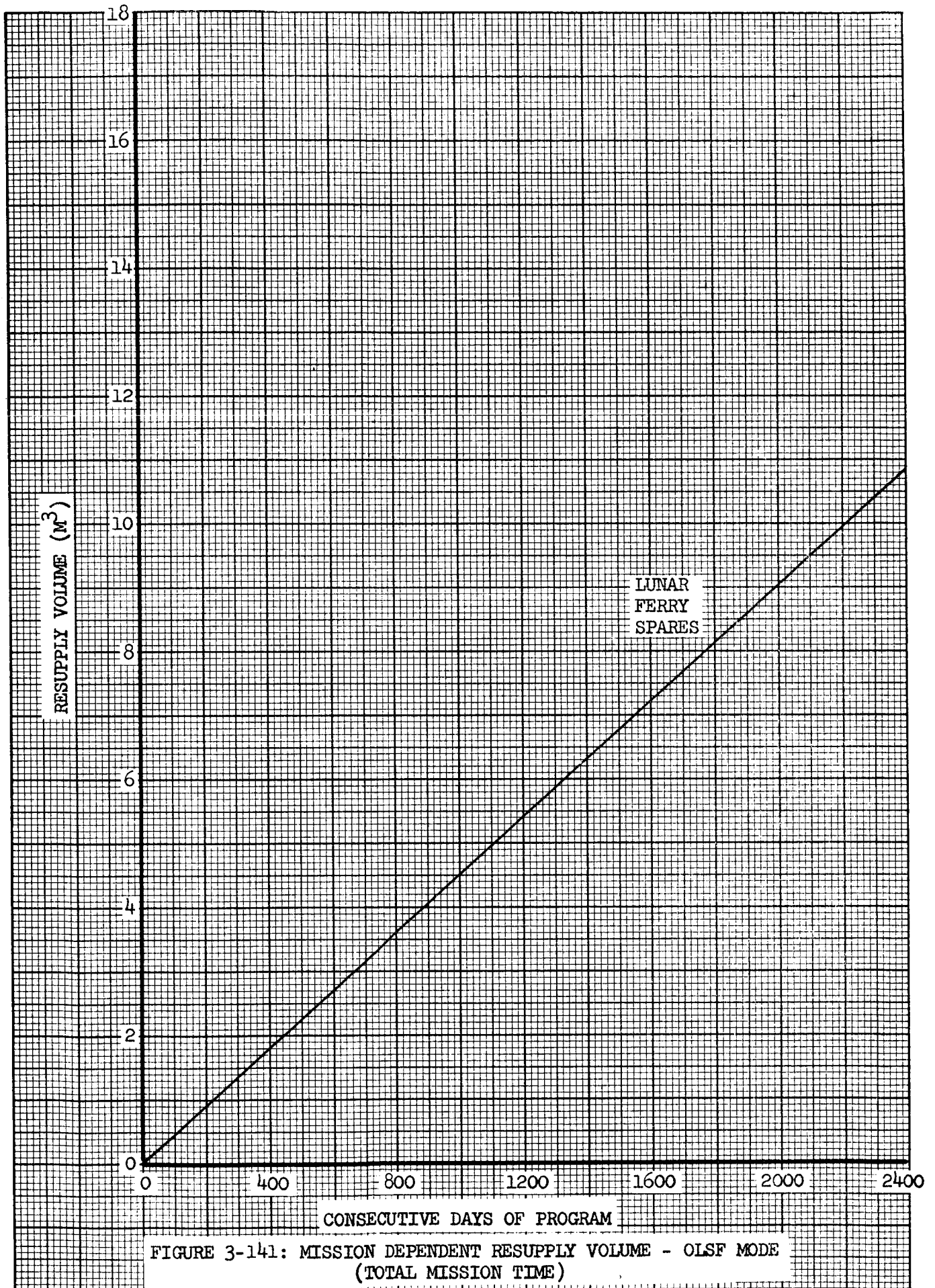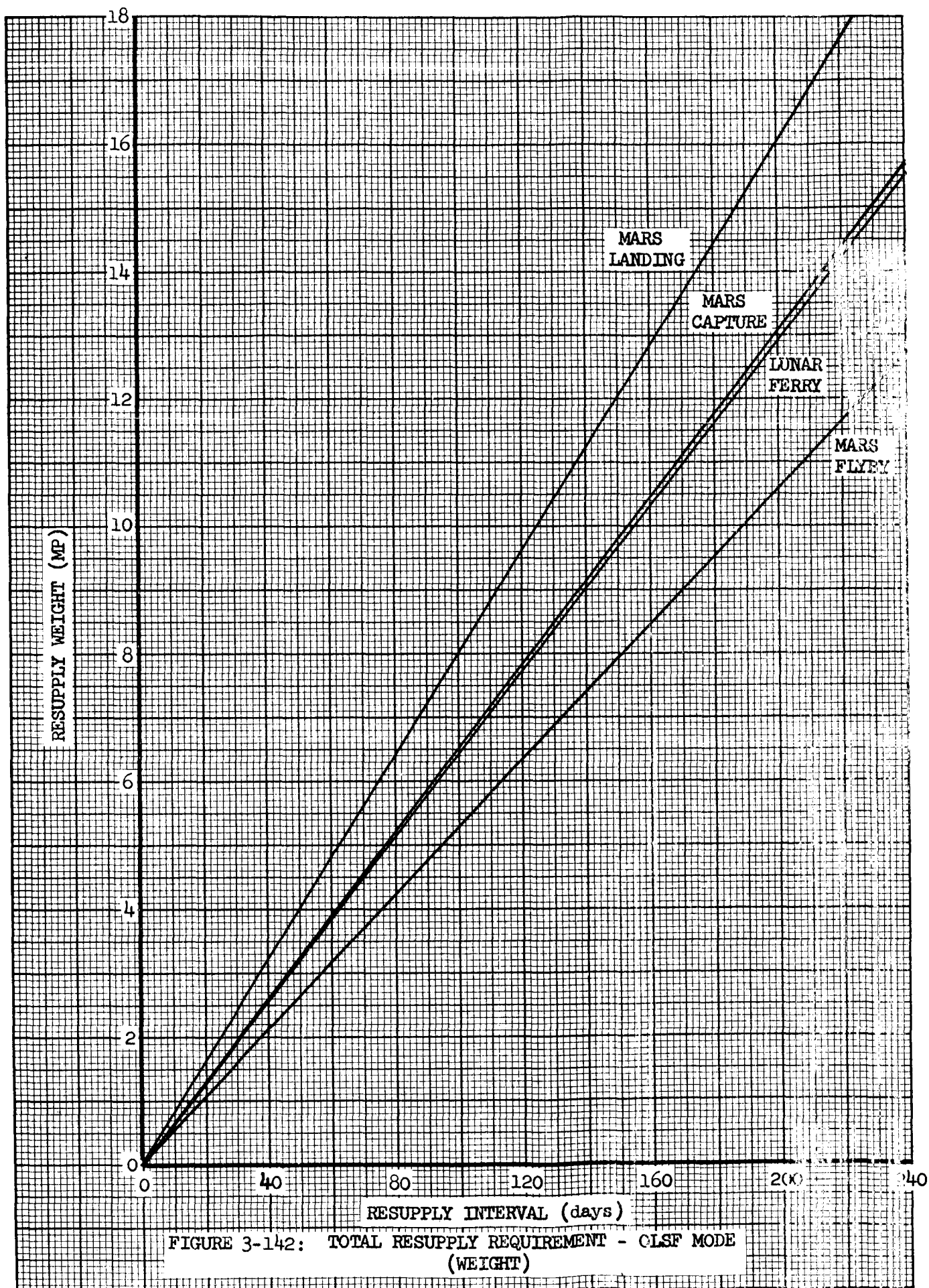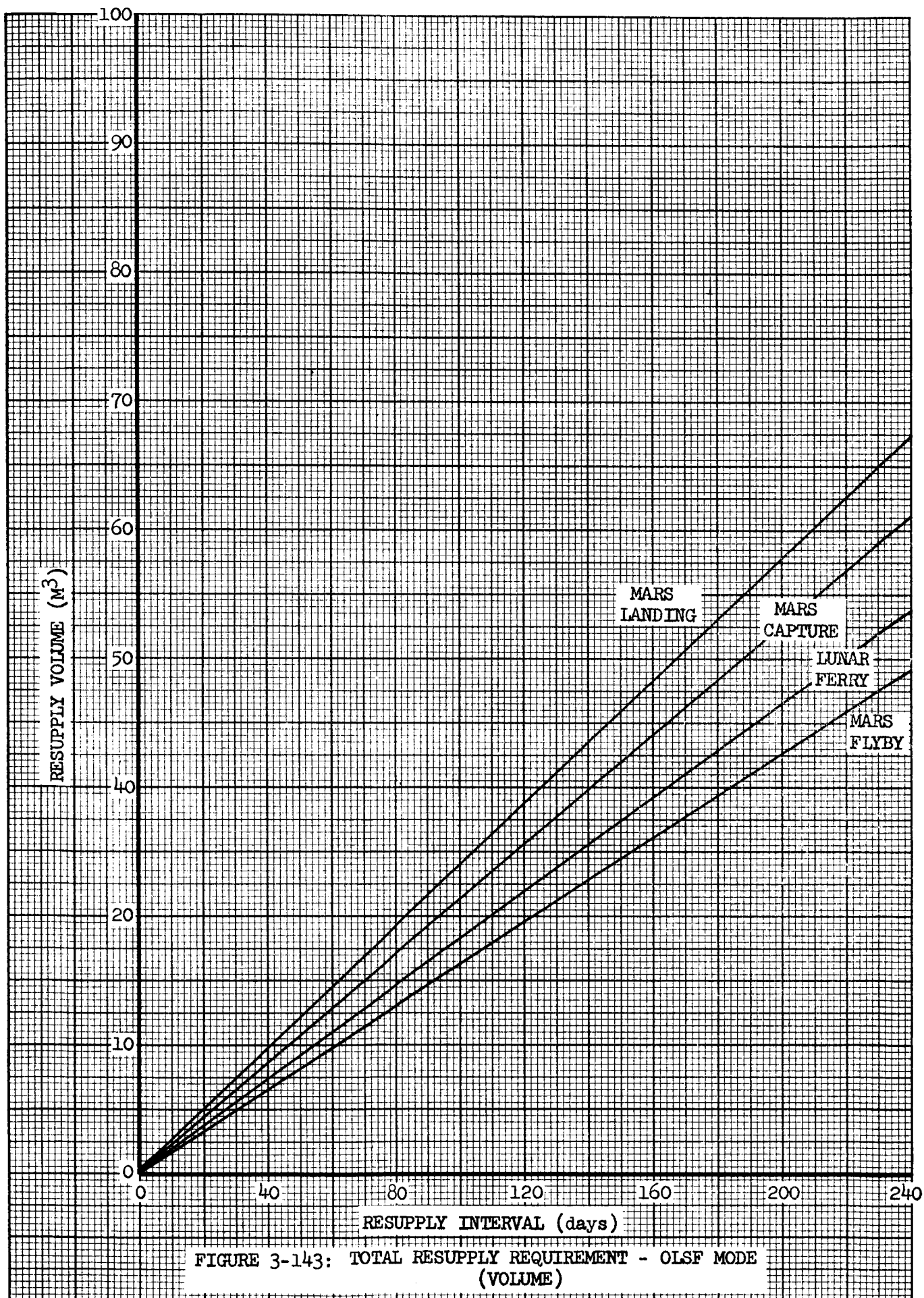
MISSION	SATURN IB			REUSEABLE ORBITAL CARRIER (ROC)		
	Resupply Interval (Days)	Number of Flights	Operating Cost ($ x 10^6)	Resupply Interval (Days)	Number of Flights	Operating Cost ($ x 10^6)
MARS FLYBY	207	8	240	164	10	100
MARS CAPTURE	168	10	300	132	12	120
MARS LANDING	137	12	360	108	15	150
LUNAR FERRY	170	16	480	134	20	200
TOTAL		46	1,380		57	570

TABLE 3-26

LOGISTICS TRANSPORTATION COST

MISSION	SIX-MAN PERSONNEL CARRIER			TWELVE-MAN PERSONNEL CARRIER		
	Passengers Per Flight	Number of Flights	Operating Cost ($ x 10^6)	Passengers Per Flight	Number of Flights	Operating Cost ($ x 10^6)
MARS FLYBY	5	27	365	10	18	162
MARS CAPTURE	5	36	486	10	18	162
MARS LANDING	5	36	486	10	18	162
LUNAR FERRY	5	45	608	10	30	270
TOTAL		144	1,945		84	756

TABLE 3-27

OLSF PERSONNEL ROTATION COST

(a) Stabilization and control propellant is eliminated since the Orbital Support Vehicle is assumed to be docked to the Orbital Launch Vehicle.

(b) Spares usage is different for the Orbital Support Vehicle than for the Orbital Launch Support Facility; this is shown in Table 3-23 .

(c) Orbital Support Vehicle propellant for orbital transfer is different from that for the OSAV (see the data in Figures 3-144 through 3-149).

The total resupply for all mission time dependent expendables is presented in Figs. 3-150 and 3-151. The 75% volumetric efficiency factor is again added, as discussed in Paragraph 3.3.2. Since resupply only occurs during the Earth orbital phase of a mission, requirements are calculated on the basis of the number of days of orbital support required in Earth orbit (see Table 3-25). Lunar Ferry spares are prorated by dividing the total spares requirement by the cumulative number of days during which Earth orbital operations occur. These totals are shown in Figs. 3-152 and 3-153. Expendables are delivered by both the Orbital Support Vehicle and an expendable logistics vehicle. However, resupply interval for this support mode has no general meaning. Accordingly, data for this item is not presented. In view of the shortness of orbital stay time for all of the guideline missions, a separate crew rotation mission is not needed.

3.4   EVOLUTION OF ORBITAL LAUNCH SUPPORT FACILITY MODE

In the following discussion, the Temporary Orbital Support Vehicle Mode, previously discussed in Paras. 3.1, is not considered. Primary emphasis is on development of a program for a permanent OLSF. The basic question is, based on the guideline missions and the Point of Departure Plan, what are the logical steps by which an OLSF may be developed? A full discussion of Orbital Launch Operations development, including the OLSF, is found in Volume II. The OLSF configurations derived and discussed previously in paragraphs 3.2.1 may be considered typical and no attempt was made to show how they might be developed. It is the intent here to discuss a method by which the OLSF mode may be developed as a function of time and mission, including the utilization, where possible, of the MORL program.

Figure 3-154 shows a development program for space stations by which the OLSF's may be developed in support of the guideline missions. Also shown (for reference) are the guideline missions and the number of personnel in orbit. The personnel are those involved in orbital launch operations, transients associated with the missions, and Earth-to-orbit ferry or logistics vehicle. It is assumed for the purposes of this discussion that the OLSF is capable of handling all of these people on a temporary basis even though under normal operational procedures the mission crews would probably bypass the OLSF.

3.4.1   Early Orbital Facilities

For purposes of this discussion, it is assumed that the Manned Orbital Research Laboratory (MORL) is a funded, hardware program which will initially be placed in orbit in early 1968. Of the two funded studies on MORL
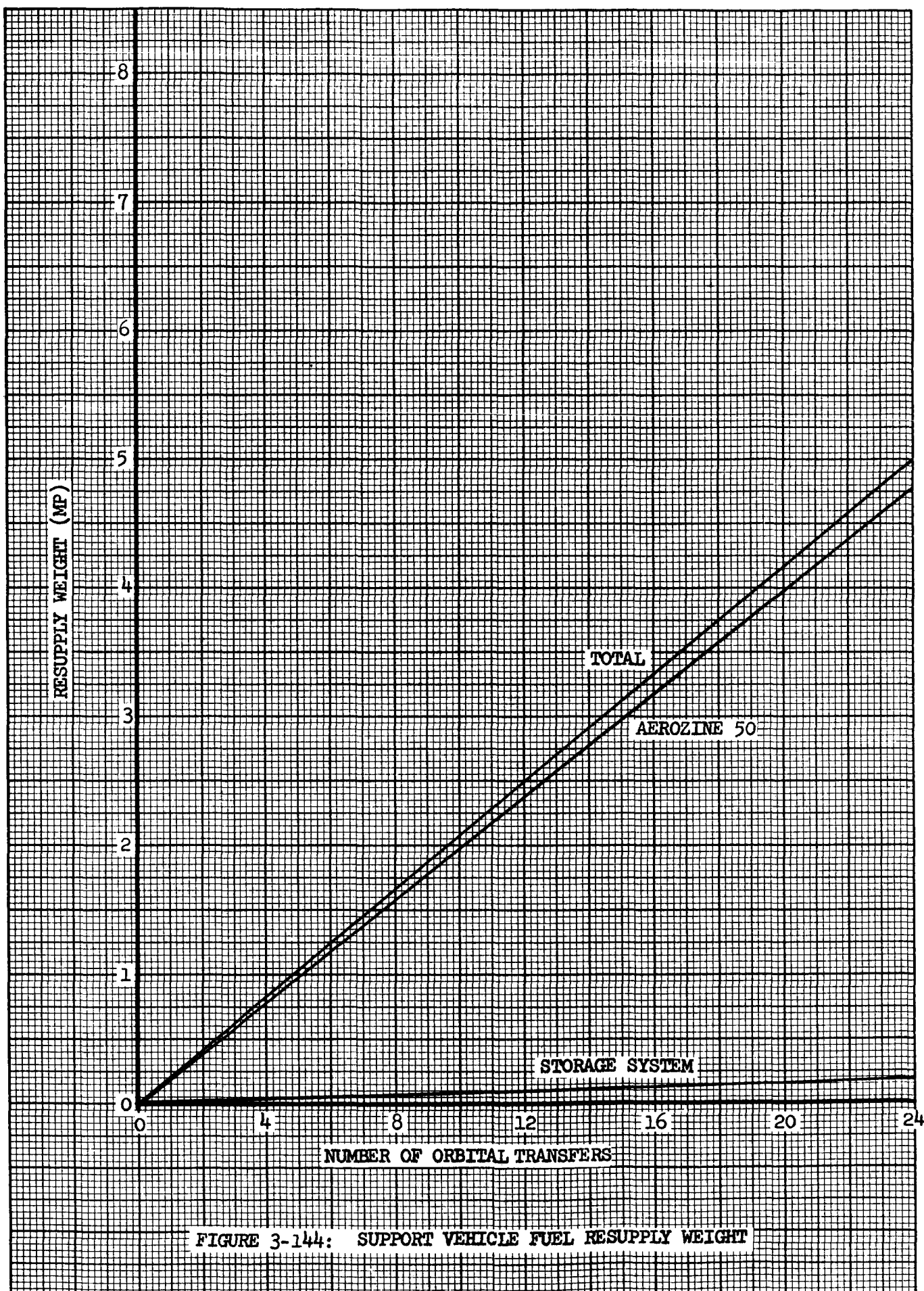
FIGURE 3-144: SUPPORT VEHICLE FUEL RESUPPLY WEIGHT

FIGURE 3-145: SUPPORT VEHICLE FUEL RESUPPLY VOLUME

3-233
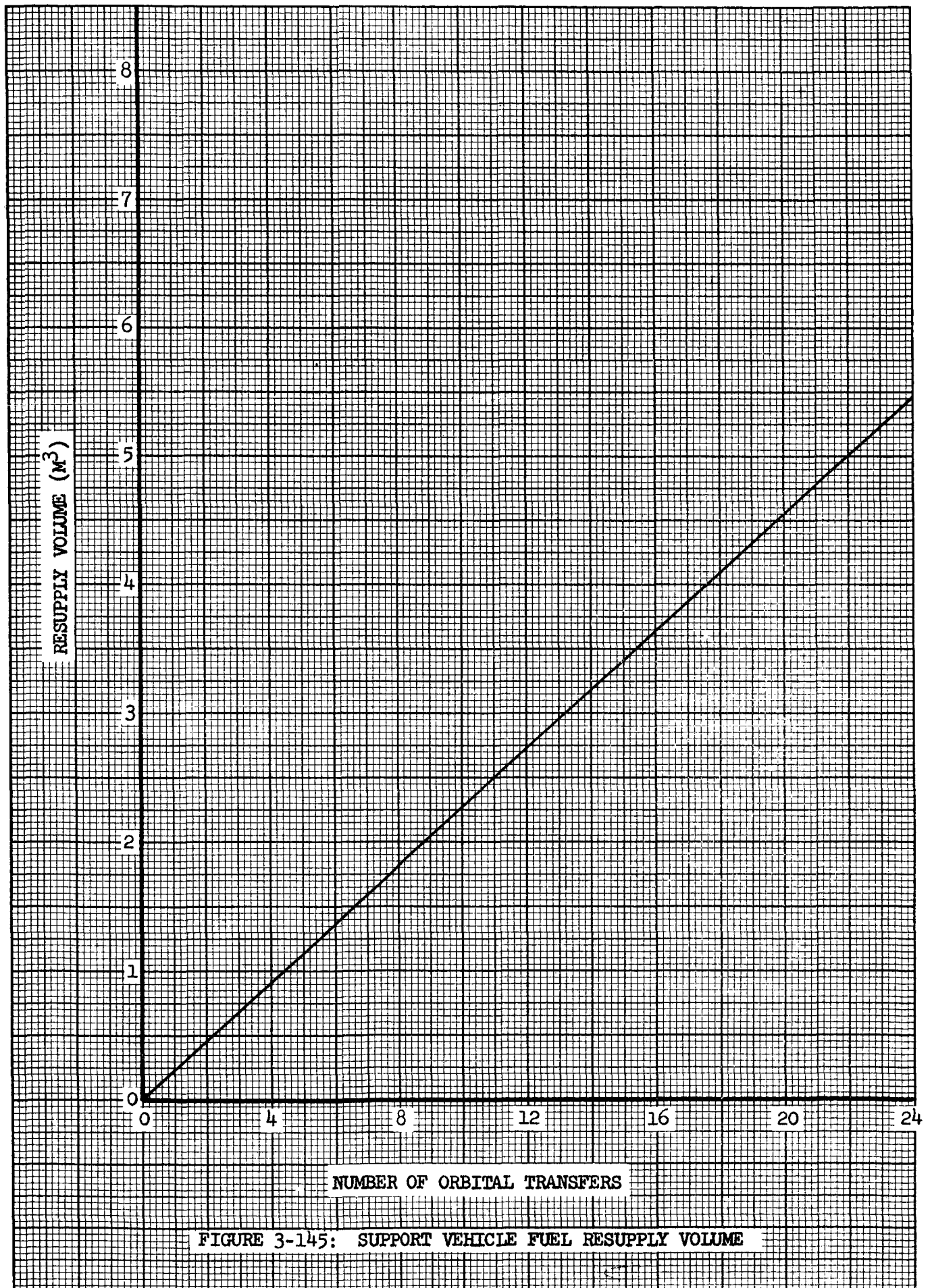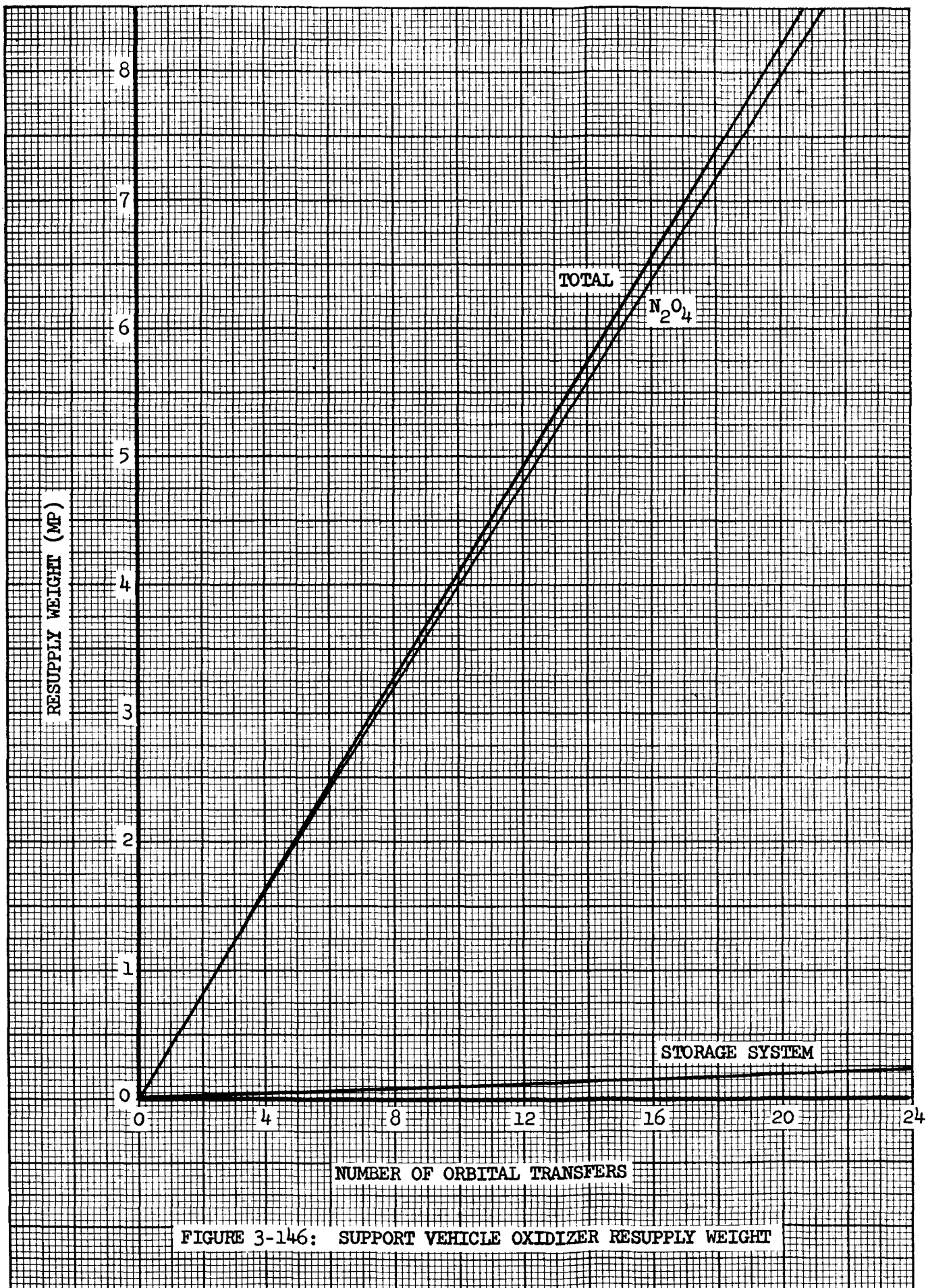
FIGURE 3-146: SUPPORT VEHICLE OXIDIZER RESUPPLY WEIGHT
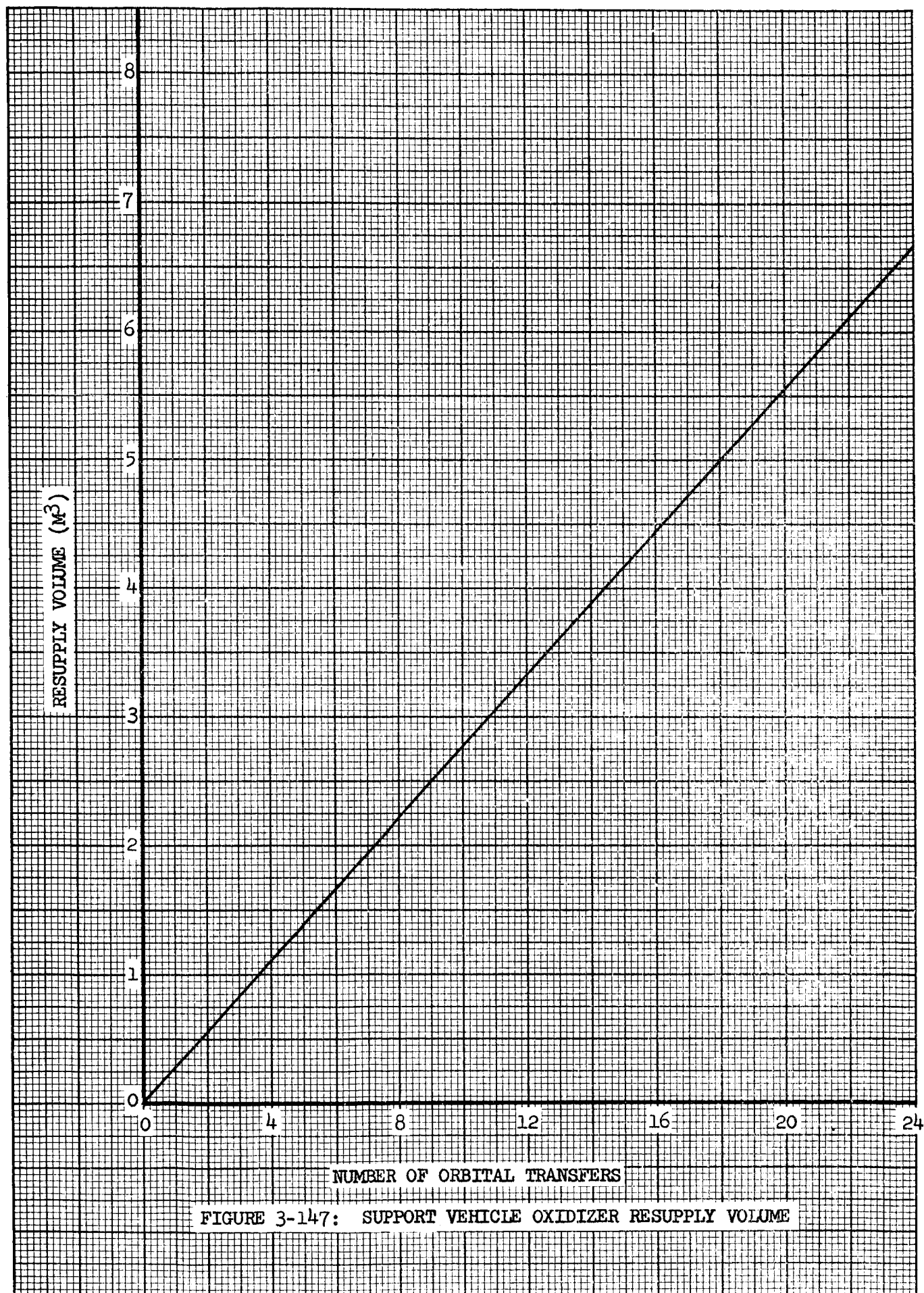
FIGURE 3-147: SUPPORT VEHICLE OXIDIZER RESUPPLY VOLUME
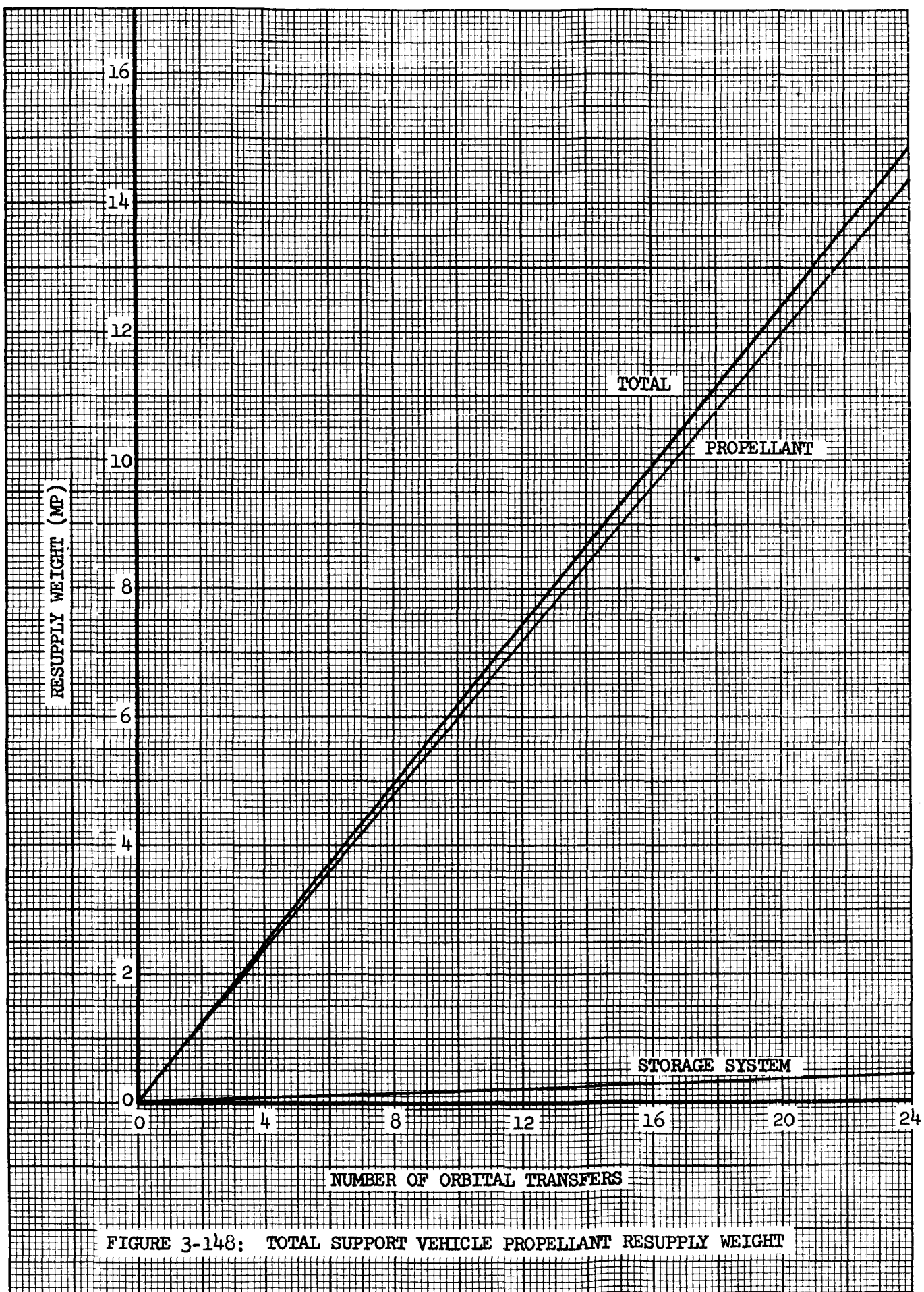
FIGURE 3-148: TOTAL SUPPORT VEHICLE PROPELLANT RESUPPLY WEIGHT

3-236
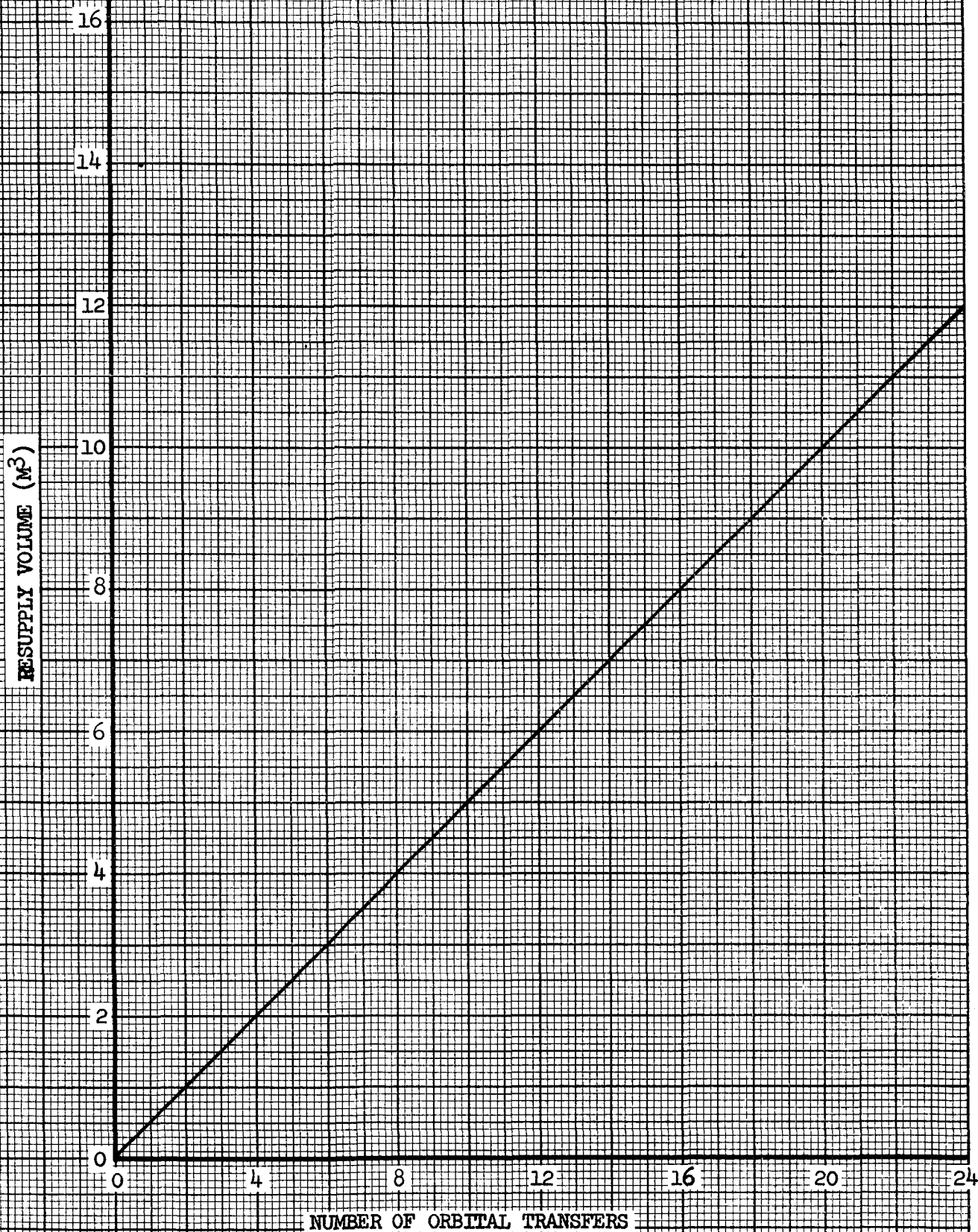
FIGURE 3-149:   TOTAL SUPPORT VEHICLE PROPELLANT RESUPPLY VOLUME

FIGURE 3-150: MISSION DEPENDENT RESUPPLY WEIGHT - SUPPORT VEHICLE MODE (EARTH ORBIT MISSION TIME ONLY)
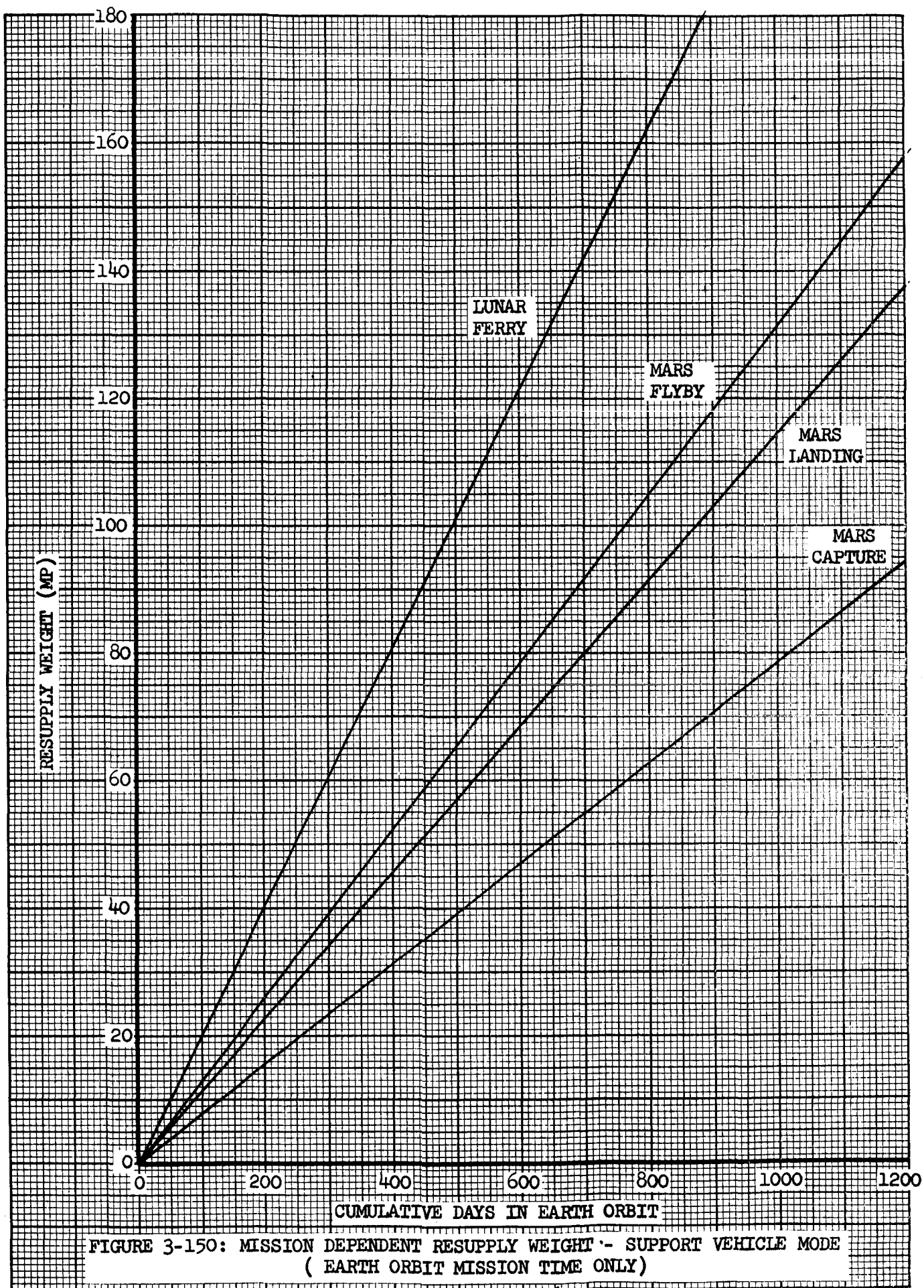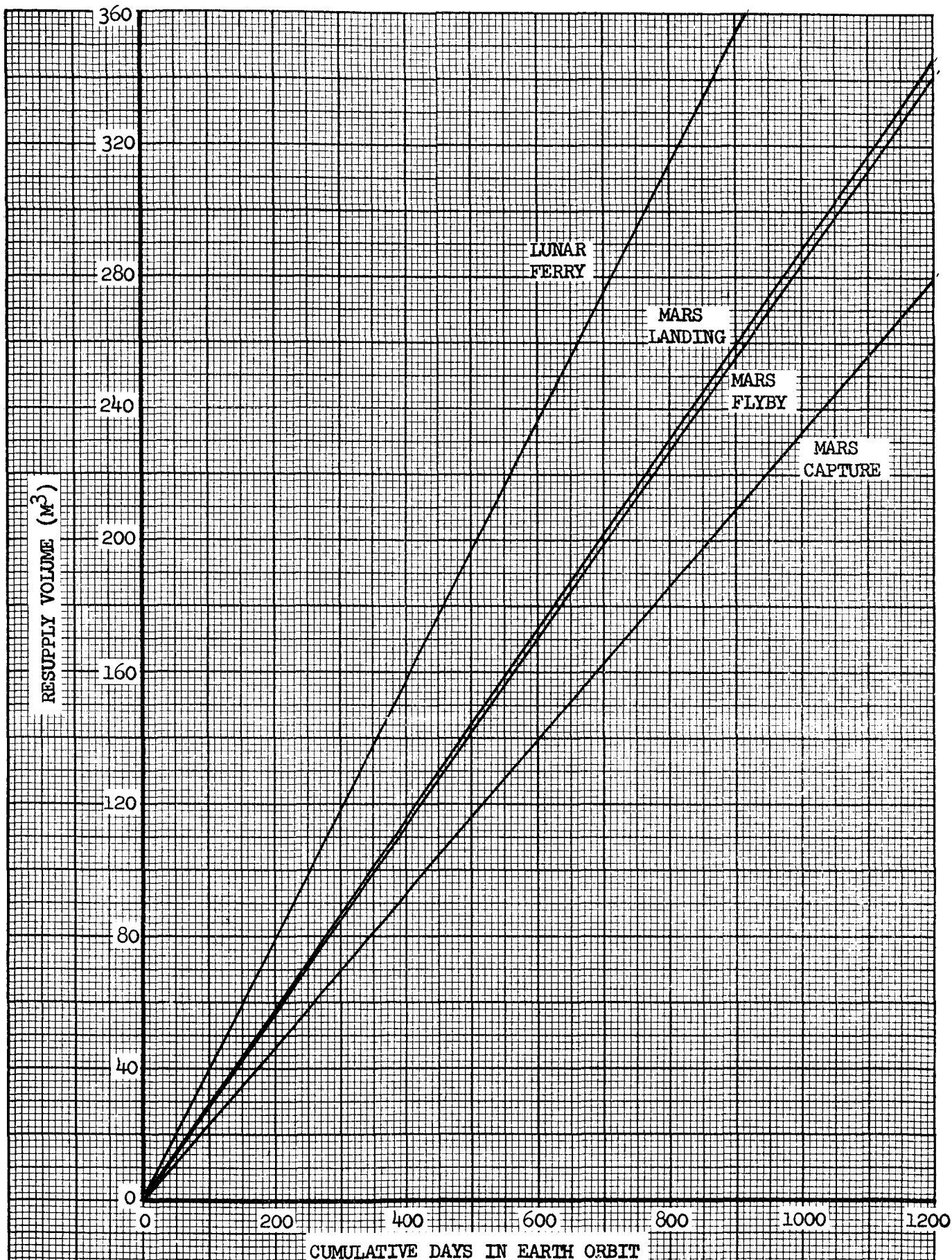
FIGURE 3-151: MISSION DEPENDENT RESUPPLY VOLUME - SUPPORT VEHICLE MODE
(EARTH ORBIT MISSION TIME ONLY)
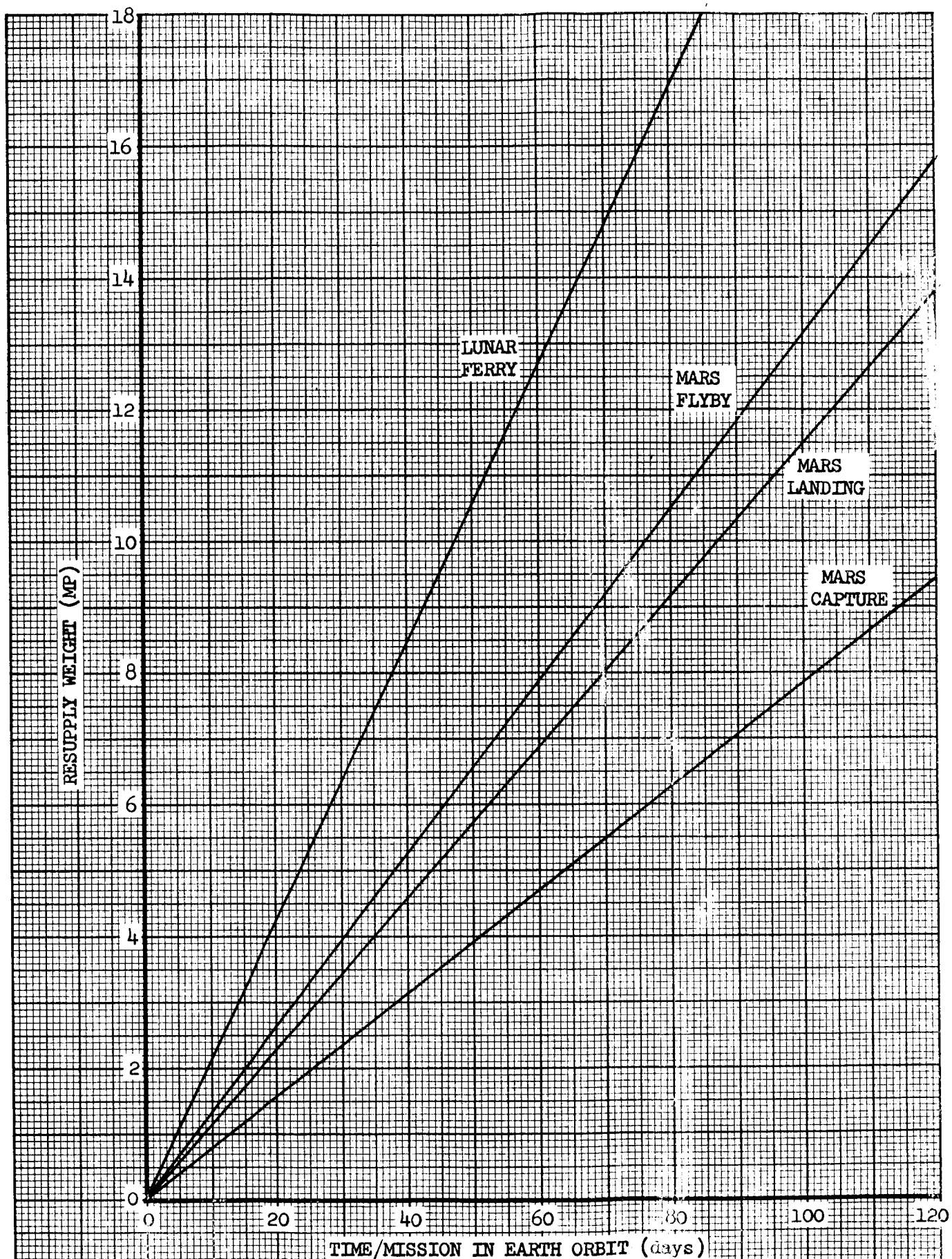
FIGURE 3-152: TOTAL RESUPPLY REQUIREMENTS - SUPPORT VEHICLE MODE (WEIGHT)

FIGURE 3-153: TOTAL RESUPPLY REQUIREMENTS - SUPPORT VEHICLE MODE (VOLUME)

FIGURE 3-154: COMPARISON OF OLSF/SPACE STATION DEVELOPMENT PROGRAMS

MISSIONS/CAL. YRS. — 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82

AOLO
BASELINE
MISSIONS — MARS FLYBY — MARS CAPTURE — LUNAR FERRY — MARS LANDING

PERSONNEL	OLO		6	13	13	13	18	18	18	18	18	14	14	18	18	18	18
ACCOMMODATED	TRANSIENT		12	3	3	3	6	6	6	6	24	24	32	32	32	32	32
IN ORBIT	TOTAL		6 12	16	16	16	24	24	24	24	38	38	50	50	50	50	50

MORL BASE
MORL - 4-6 MEN
  Development
  Launch/Mission — SATURN IB LAUNCH

TWIN MORL - 8-12 MEN
  Development
  Launch/Mission — 2 SATURN IB LAUNCHES

LARGE STATION - 16-24 MEN
  Development
  Launch/Mission — SATURN V LAUNCH

LARGE STATION - 50-60 MEN
  Development
  Launch/Mission — SATURN V LAUNCH

LARGE SPACE STATION - BASE

ROTATING STATION - 16-24 MEN
  Development
  Launch/Mission — SATURN V LAUNCH

(Proposed Launch to Provide State-of-the-Art Equipment)

LARGE STATION - 50-60 MEN
  Development
  Launch/Mission — SATURN V LAUNCH

[===] DEVELOPMENT

3-242

(References 15 and 16), Reference 15 is selected as a basis on which to develop the OLSF program. From Reference 15 the following pertinent information is derived:

> The MORL system will resolve the following key questions affecting the future of the National Space Program:
>
> - Man's psycho-physiological tolerance and proficiency under long-term weightlessness conditions.
>
> - The physical laws and phenomena which affect the performance of future spaceborne vehicles and equipment.

The key to the space station/OLSF concept is the experimental program, currently the subject of much work by NASA, other government agencies and industry. The prime MORL goal is the achievement of a universal test bed with flexibility being a major system design consideration. Thus, the MORL system has the following characteristics.

- A laboratory sufficiently large to accommodate varied experimental gear and a crew adequate to operate the laboratory and to perform the experiments. The design of Reference 15 provides for a normal crew complement of six men with a peak capacity of eight men and the ability to sustain (or operate) the laboratory with only two men.

- Provision, in the event weightlessness should prove intolerable, for continuous artificial gravitation by rotation of the laboratory. Data on weightlessness from additional manned space flights prior to the launch of MORL may modify this requirement. Rotation requires deployment mechanisms, a more complex attitude control system, and additional propellant. However, it is likely that the effects of weightlessness can be offset by such measures as exercise and centrifugation, so rotation may be unnecessary.

- A simple, proven experimental procedure. The design, interpretation, and redirection of the experiments requires diverse scientific disciplines too numerous and specialized to be provided by the crew. The primary qualifications for the crew are physical fitness, operational proficiency, and the engineering ability necessary to execute the experiments. The experiments are designed on the ground, procedural instructions are transmitted to the crew, and experimental data with crew observations are relayed to the ground for interpretation. The crew's ability to implement redirection provides a response and flexibility unavailable in unmanned space vehicles.

The MORL system is comprised of (1) a laboratory in a circular orbit at an optimal altitude of 200 nautical miles and an inclination of 28.7 degrees, (2) Gemini ferries for rotation of the crew, (3) modified Atlas/Agena D resupply spacecraft, and (4) a ground support complex. The laboratory is launched unmanned by means of a Saturn IB launch vehicle; the crew is sent up later in Gemini vehicles to activate the laboratory systems. The laboratory contains enough consumables to last until the arrival of the first resupply spacecraft, plus reserve supplies for 45 days. Logistics spacecraft provide for crew rotation and replenish the consumables using rendezvous and docking techniques developed for the Gemini-Agena program.

The laboratory weighs 10,749.5 kp (23,649 lbs.) and consists of a 260 inch diameter spherical pressure shell encased within an outer load-carrying shell. The pressure shell provides cabin pressure integrity; both shells protect against meteoroids and radiation. The laboratory is equipped with a dual capability for producing artificial gravity. A centrifuge provides intermittent artificial gravity, and a back-up deployment-rotation mechanism provides continuous artificial gravity. Initially the laboratory is operated at zero g. In this condition, the centrifuge has a threefold application: (1) as an experimental tool, (2) as a potential therapeutic-device, and (3) as a conditioning device for preparing the astronauts to withstand re-entry. If continuous artificial gravity is found to be necessary, the spent S-IVB stage is used as a counterweight, deployed away from the laboratory by means of a strut-cable system, and the assembly is rotated.

The laboratory is equipped to perform experiments in three broad categories; i.e., bio-medical, behavioral, and engineering and scientific experiments. Many of the proposed experiments are directly applicable to Orbital Launch Operations.

Figure 3-155 shows a general arrangement of the MORL facility.

3.4.2   MORL Follow-On

Referring back to Figure 3-154, one method of developing an Orbital Launch Support Facility is to use the MORL concept and facility as a basic building block. For example, Figure 3-156 shows two different, 12 man Orbital Launch Support Facilities based on a twin-MORL concept; one is shown with artificial gravity and the other with zero gravity. The MORL experimental program is designed to supply the answer to the question of the need for artificial gravity; when such an answer is available, only one of the twin MORL concepts shown can be pursued. The capacity of the MORL facility and the number of men required in orbit for orbital launch operations are such that two MORL's, coupled together and suitably modified could adequately perform the job of an OLSF for the Mars Flyby mission. Applicable Orbital Launch Operations techniques would, to a large extent, already have been developed with the original MORL. Examples of typical orbital launch operations for which equipment and techniques will have to be worked out, whether on the original MORL or on the twin MORL/OLSF, are as follows:

(1) Assembly or erection of mission vehicle modules

(2) Propellant transfer

SECTION C-C
LIVING QUARTERS TIER

SECTION B-B
OPERATIONS/EXPERIMENTAL TIER

SECTION A-A

SOLAR CELL ARRAY
(EXTENDED)

SOLAR CELL ARRAY
(STOWED)

6.6 M DIA.
(260 IN.)

CENTRIFUGE

DOCKING PORT

AIRLOCK
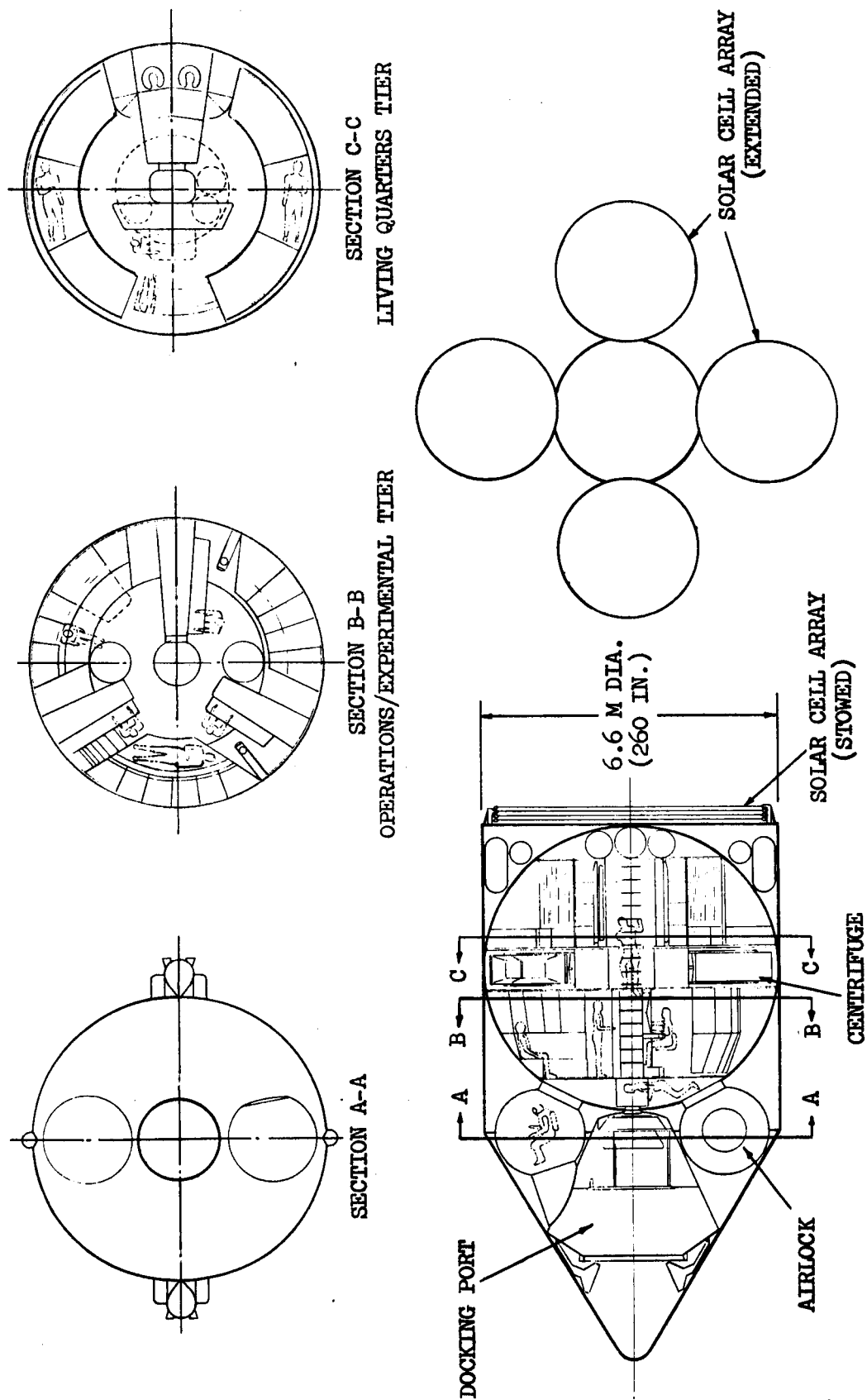
FIGURE 3-155: ZERO G MORL GENERAL ARRANGEMENT

SOLAR ARRAY

CABLE EXTENSION SYSTEM

ARTIFICIAL GRAVITY
TWIN MORL/OLSF

ALTERNATE SOLAR
ARRAY

MORL INTERCONNECT

GEMINI (REF)

MODIFIED MORL

6 MAN MODAP (REF)

SOLAR ARRAY (TYP)
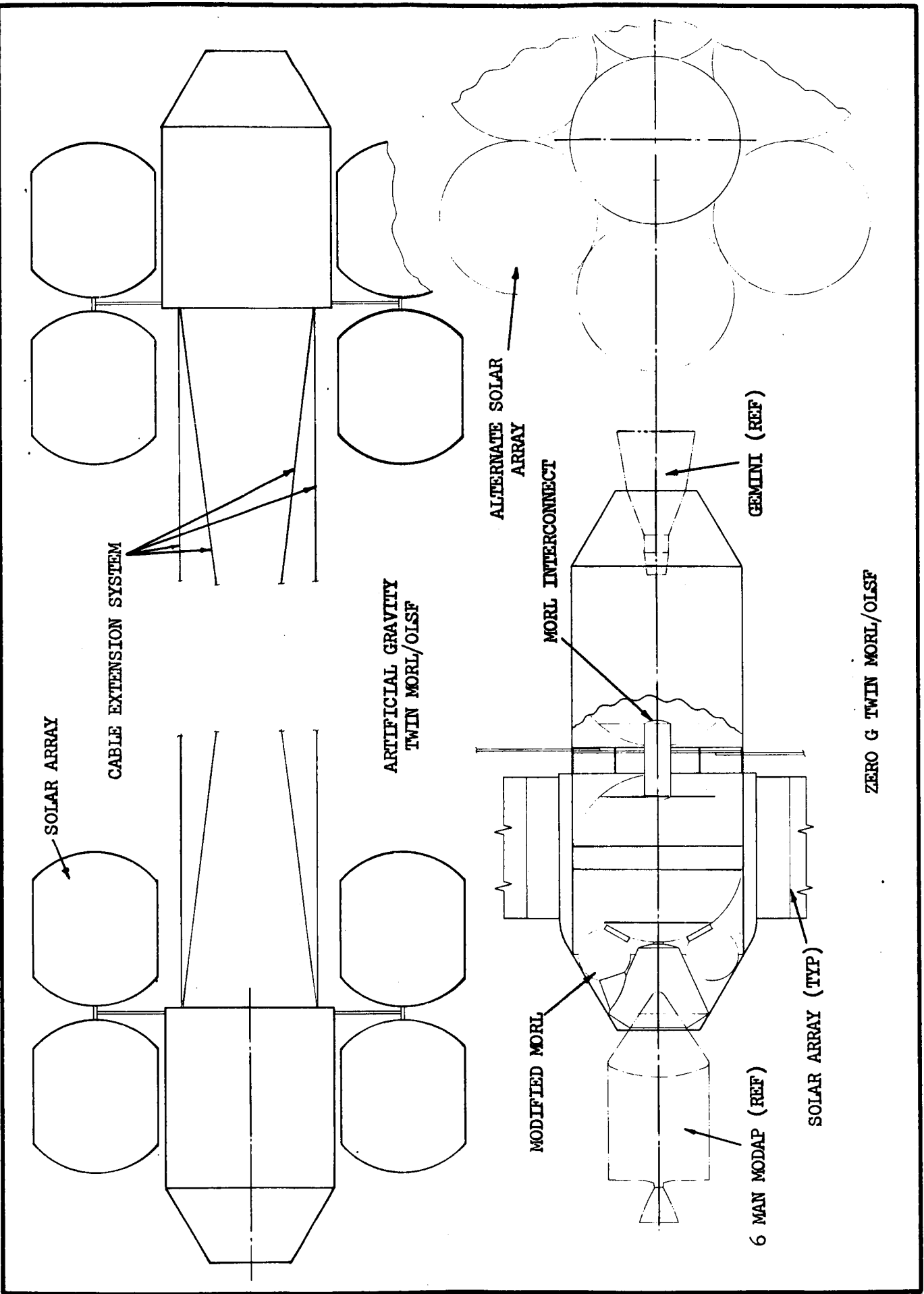
ZERO G TWIN MORL/OLSF

FIGURE 3-156: TWIN MORL OLSF'S

(3) Intervehicle ferry techniques

(4) Extravehicular inspection

(5) Repair techniques

(6) Spares replacement

(7) Vacuum welding

The zero "g" MORL/OLSF would have to be suitably modified to permit end-to-end assembly and to provide an air lock between the two MORL's. To assemble the MORL's in this fashion requires orbital assembly of the MORL's since their gross weight exceeds theSaturn IB capability. As an alternative they could be pre-assembled on the ground prior to launch; however, this would require the use of a Saturn V launch vehicle. Further modification of the MORL's may be required in the area of the solar cells arrays. The outwardly rotated solar cell discs may not be compatible with end-to-end assembly; a different type of solar cell deployment, similar to that shown, may be required.

3.4.3   Large OLSF/Space Station

Following the development of the twin MORL's as a first generation OLSF comes the next step; the establishment of a large OLSF/space station. This facility is required by the larger number of personnel in orbit for both the Orbital Launch Operations checkout crew and the mission crew. There are at least two possible approaches to this facility as shown in Figure 3-154. One approach makes further use of the MORL as a basic building block and consists of an assembly of four MORL's which would provide quarters for up to 24 men. Three different zero g configurations of a four MORL assembly are shown in Figure 3-157 and 3-158. These are a spoked configuration, a linear configuration, and a side-by-side clustered configuration. All of these configurations require rework and modification to the basic MORL structure to permit these different arrangements.

In the case of an artificial "g" assembly, there are perhaps three arrangements that might be considered. Two of these involve an extended cable arrangement similar to that proposed in Reference 15 for the MORL. In one case the four MORL's are assembled together in a side-by-side cluster while at the other end of the cables are the spent S-IVB stages, also in a cluster of four. The alternative to this configuration is to divide the MORL's into two assemblies of two each, one on each end of the cable arrangement. Both of these methods have serious operational problems, particularly with regard to the lack of a zero "g" hub where support vehicles can be docked. Accordingly, a third approach lends itself to consideration. This approach involves the assembly of four MORL's in a spoke configuration, which requires the addition of a zero "g" hub and spokes for attachment of the several MORL's. All of these methods, whether zero "g" or artificial "g," require multiple Saturn IB launches (either four or five launches depending on how much additional hardware is required). Stacking of four MORL's on a Saturn V, even though within the payload capability of the launch vehicle, is probably unacceptable due to the long length and the resulting increase in bending loads on the payload and launch vehicle.

MODIFIED MORL (TYP)

MORL INTERCONNECT
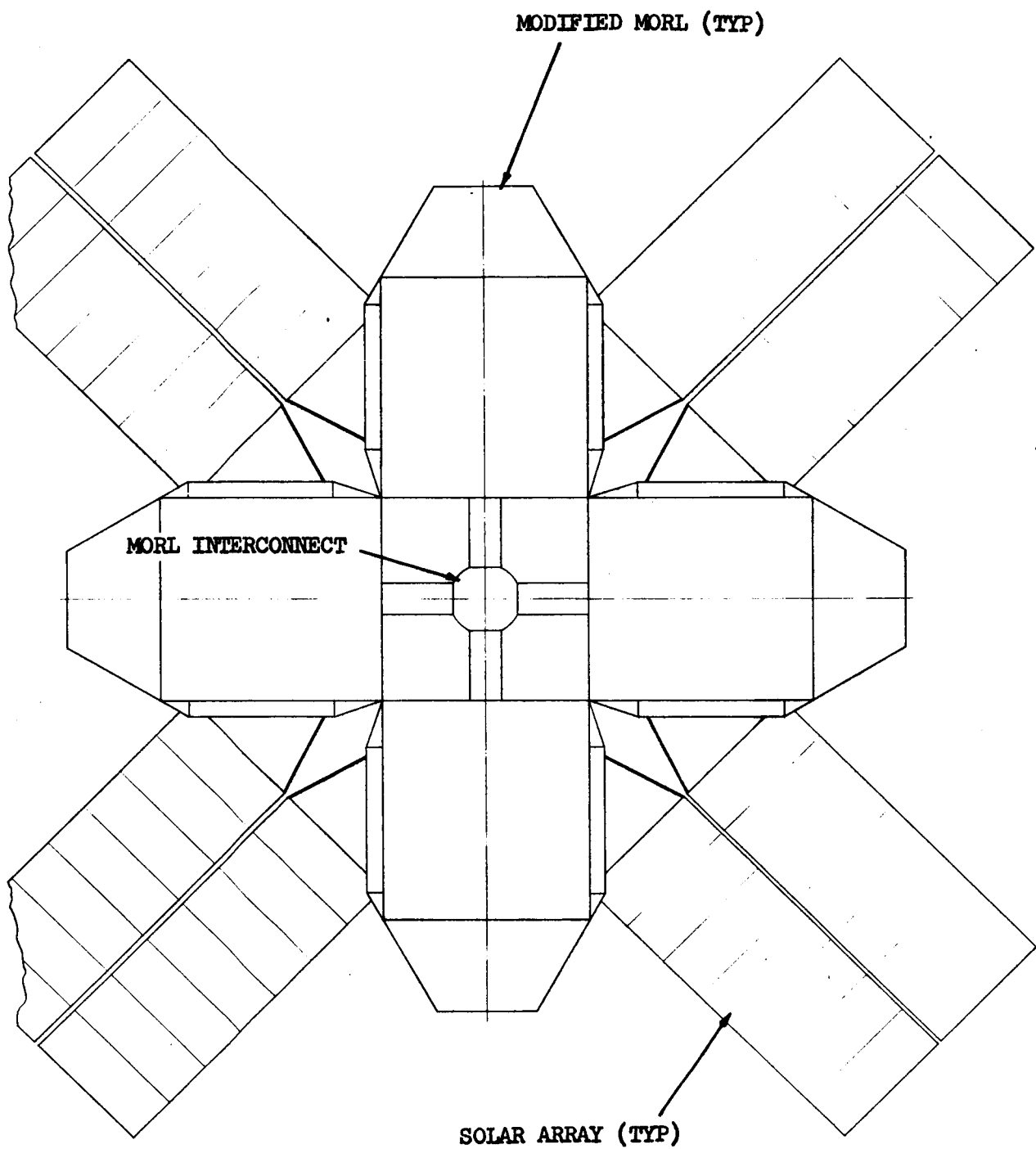
SOLAR ARRAY (TYP)

FIGURE 3-157: ZERO GRAVITY 4 MORL/OLSF
"SPOKED CONFIGURATION"

3-248

ADDITIONAL DOCKING PORTS

SOLAR ARRAY (TYP)

INTERCONNECTS

LINEAR CONFIGURATION

MORL/OLSF
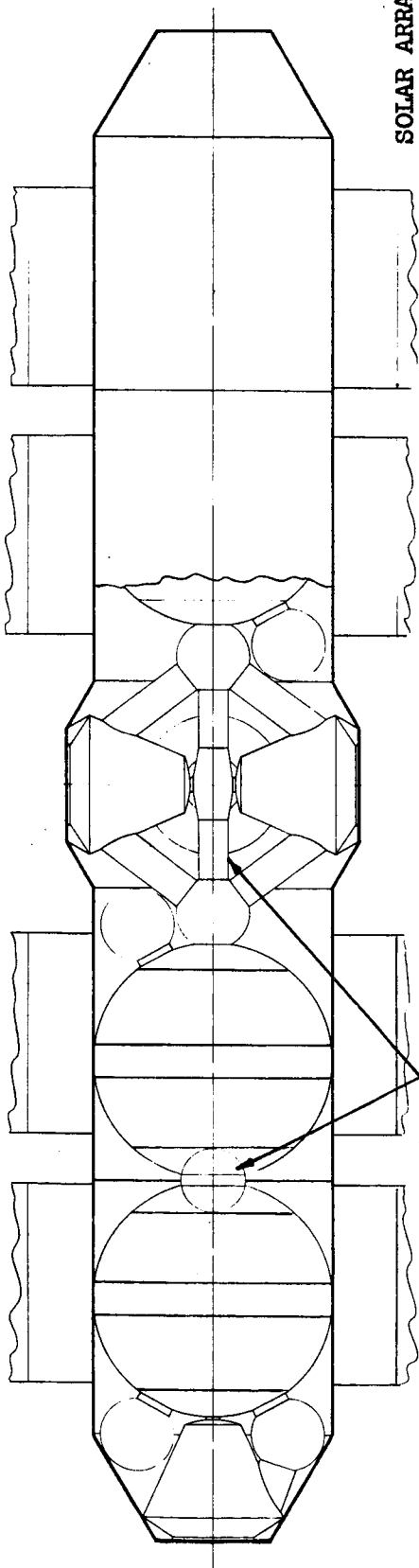
SOLAR ARRAYS (TYP)

SIDE-BY-SIDE
CLUSTERED CONFIGURATION

INTERCONNECT
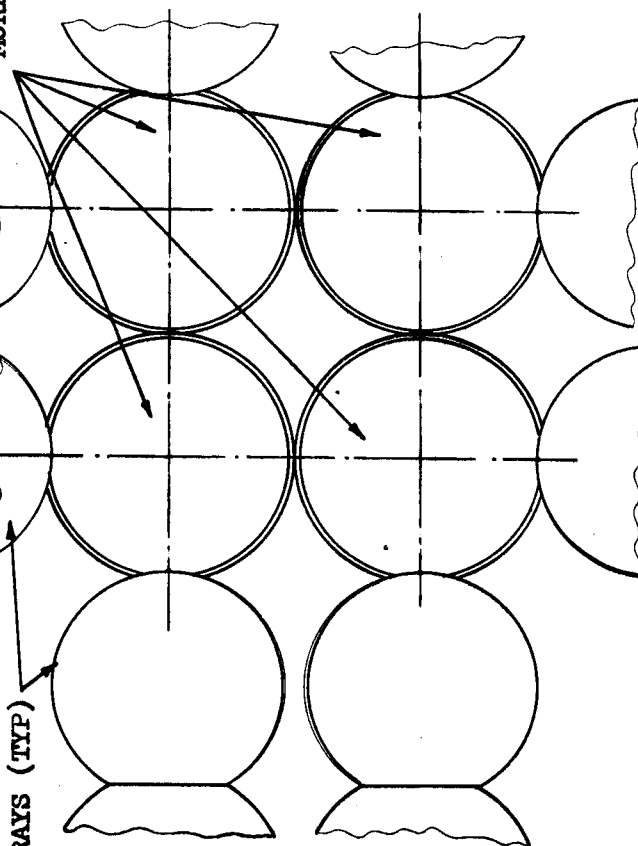
FIGURE 3-158: ZERO GRAVITY 4 MORL/OLSF'S

An alternate approach to the large OLSF/space station is to design a new large facility, making use of the MORL developed techniques and technology. This facility must have from 24 to 36 men and is placed in orbit in 1972 to be compatible with the guideline mission personnel build-up. It is presumed that by the time this facility is designed, an answer to the question of gravity requirements will be known. Should there be a question, however, the recommended approach is to design the facility based on artificial "g" requirements (i.e., a rotating facility) and if artificial gravity is determined not to be necessary, the Orbital Launch Support Facility would simply not be rotated.

Another approach to the development of the OLSF is as shown on the bottom of Figure 3-154. This approach is to bypass the MORL program entirely and proceed initially with the design and development of a large rotating space station with Orbital Launch Operations capabilities. Thus, if the MORL program shows that artificial gravity is required, the capability to provide this requirement will exist immediately. If otherwise, then it will not be necessary to rotate the Orbital Launch Support Facility. Based on current data, there is no apparent reason why large space stations, currently under study by and for NASA, cannot be modified and adapted to serve as an Orbital Launch Support Facility in addition to its other functions. The conversion of a space station to an Orbital Launch Support Facility requires a minimum of change in subsystems; the primary changes are in the area of checkout and countdown equipment and spares (for the Lunar Ferry only). Depending on the weight and volume characteristics of the space station, these items may be added to already planned subsystems or if the weight and volume limits are exceeded, it is necessary to remove some lower priority equipment. Later Orbital Launch Support Facilities in the evolutionary stream may require larger personnel capacity in which case a new design may be required. For example, if the Lunar Ferry and Mars Landing missions are conducted concurrently and the same facility is used for both missions, as many as fifty people (including mission crews) may be in orbit at the same time for relatively short periods of time (of the order of 3-10 days). This indicates that one possible solution is not to provide a larger facility but simply to provide a second orbital launch support facility of the same kind developed earlier in 1972. Then for the short periods of time necessary to house additional personnel, a sharing of facilities (such as beds) can be instituted. Free volume per man, normally several hundred cubic feet per man, would, even at a reduced level of around 200 cubic feet per man, not be intolerable for the time intervals under consideration.

Examples of the large space stations which, with suitable modification, could be adapted to the role of an Orbital Launch Support Facility are shown in Figures 3-159, 3-160, and 3-161. Figure 3-159 shows the NASA LRC rotating, artificial gravity, 24 man space station. This station consists of six tangential interconnected, functional modules; these modules are folded into a launch configuration and after injection into orbit are self-erectable to the configuration shown in the figure. Figure 3-160 shows the NASA MSC artificial "g", 24 man space station. This station uses an arrangement of three radial spokes, folded for launch, and deployed after arrival in orbit. Figure 3-161 shows the NASA MSC zero "g" 24 man space station which utilizes a cylindrical can arrangement. From the studies reported in References 17, 18, 19, and 20 there are no insurmountable engineering problems associated with any of these stations. All of them are within the launch capability of the Saturn V and are capable of being

22.8 M
(75 ft.)

19.8 M
(65 ft.)

10 M DIA.
(33 ft.)

A

A

DOCKING HUB

3 M DIA.
(10 ft)
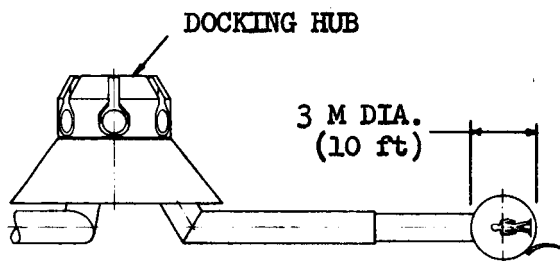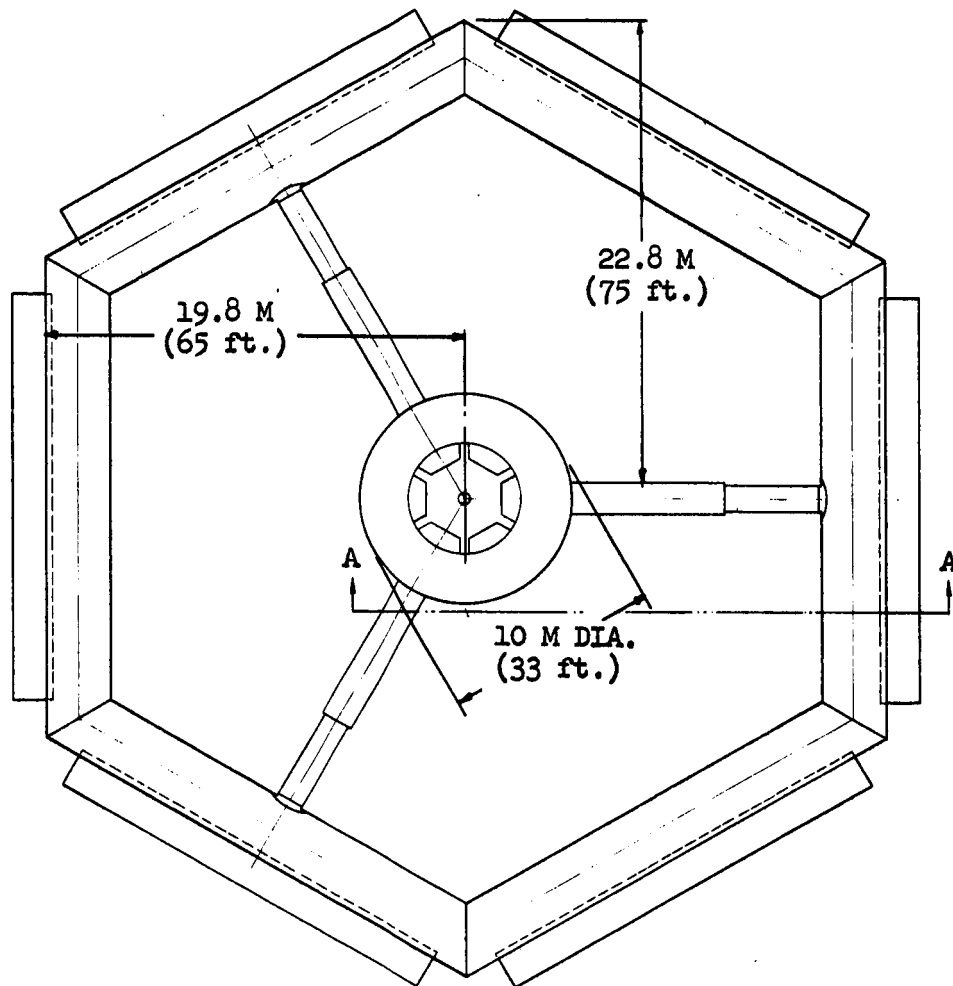
SECTION A-A

FIGURE 3-159: NASA LRC ROTATING SPACE STATION

3-251

14.5 M
(47.5 ft)

24.1 M
(79.2 ft)R

10 M DIA.
(33 ft)

4.64 M DIA.
(15.2 ft)

SOLAR CELL ARRAY

HANGAR DOOR

24.9 M
(81.6 ft)
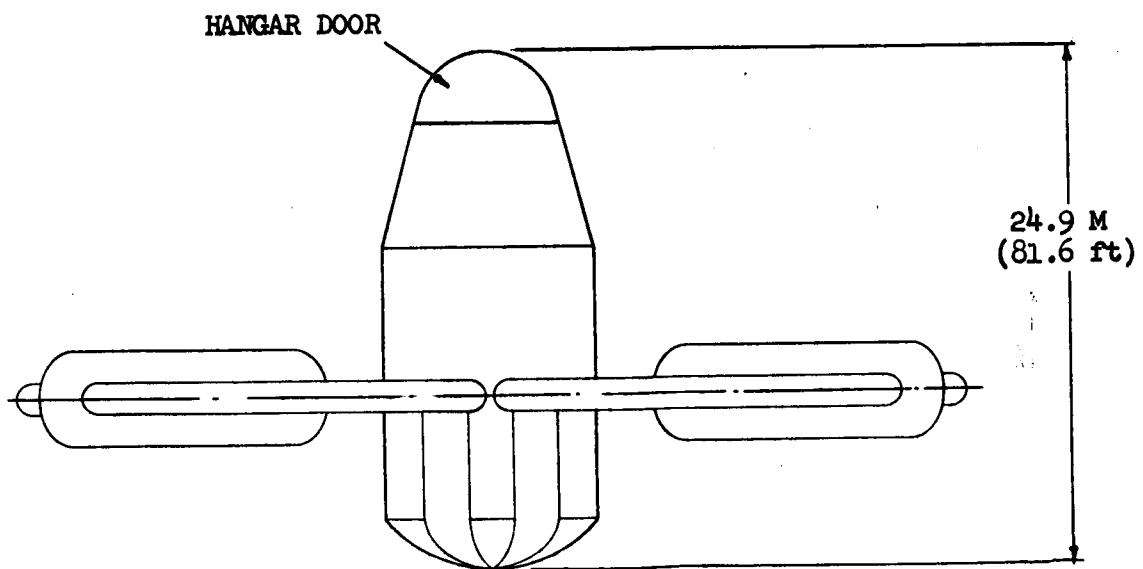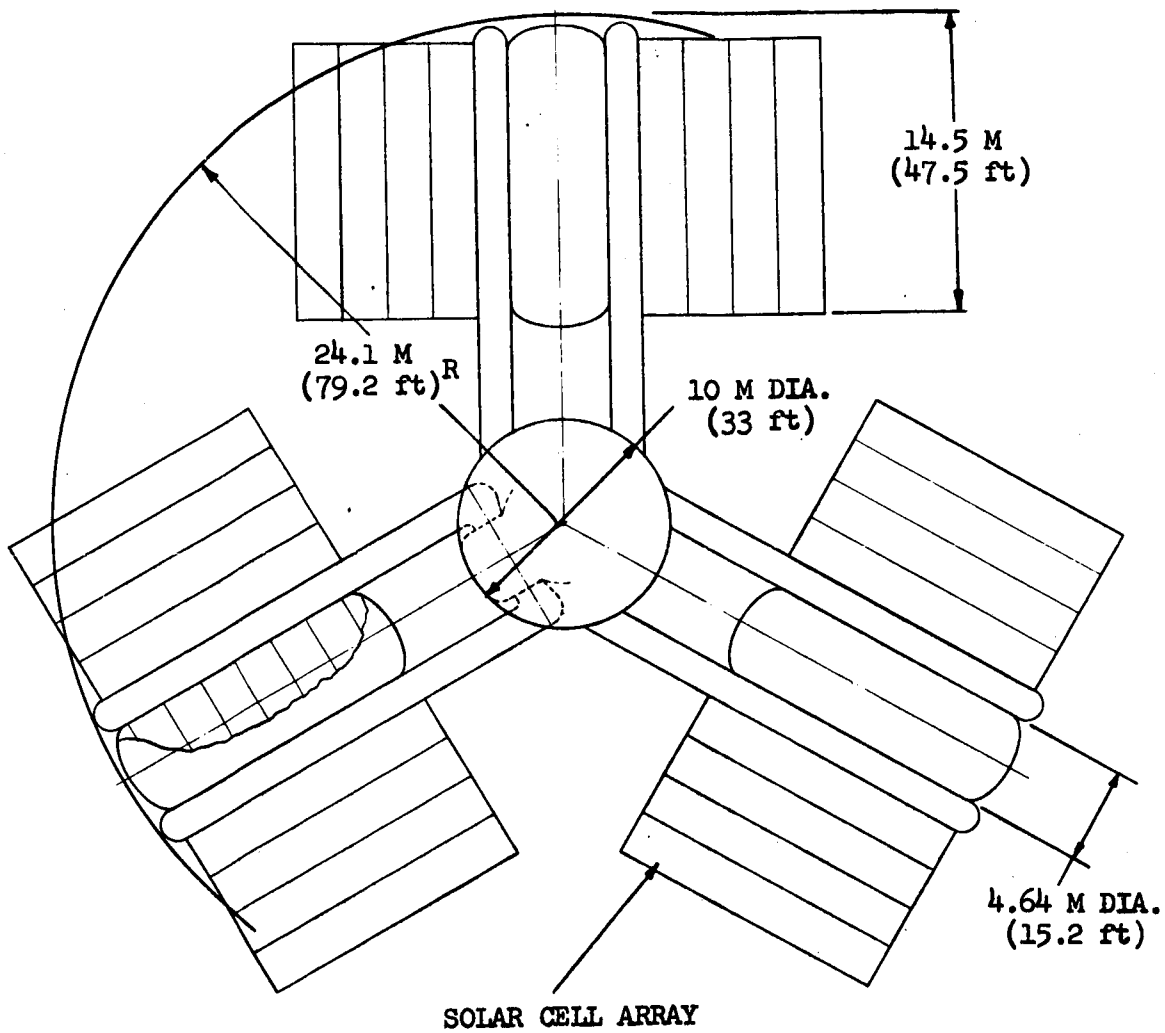
FIGURE 3-160: NASA MSC ROTATING SPACE STATION

CREW QUARTERS/
COMMAND CENTER

LABORATORY   STORAGE

HANGAR

10 M DIA.
(33 FT)

30.5 M
(101 ft)

SOLAR CELL ARRAY
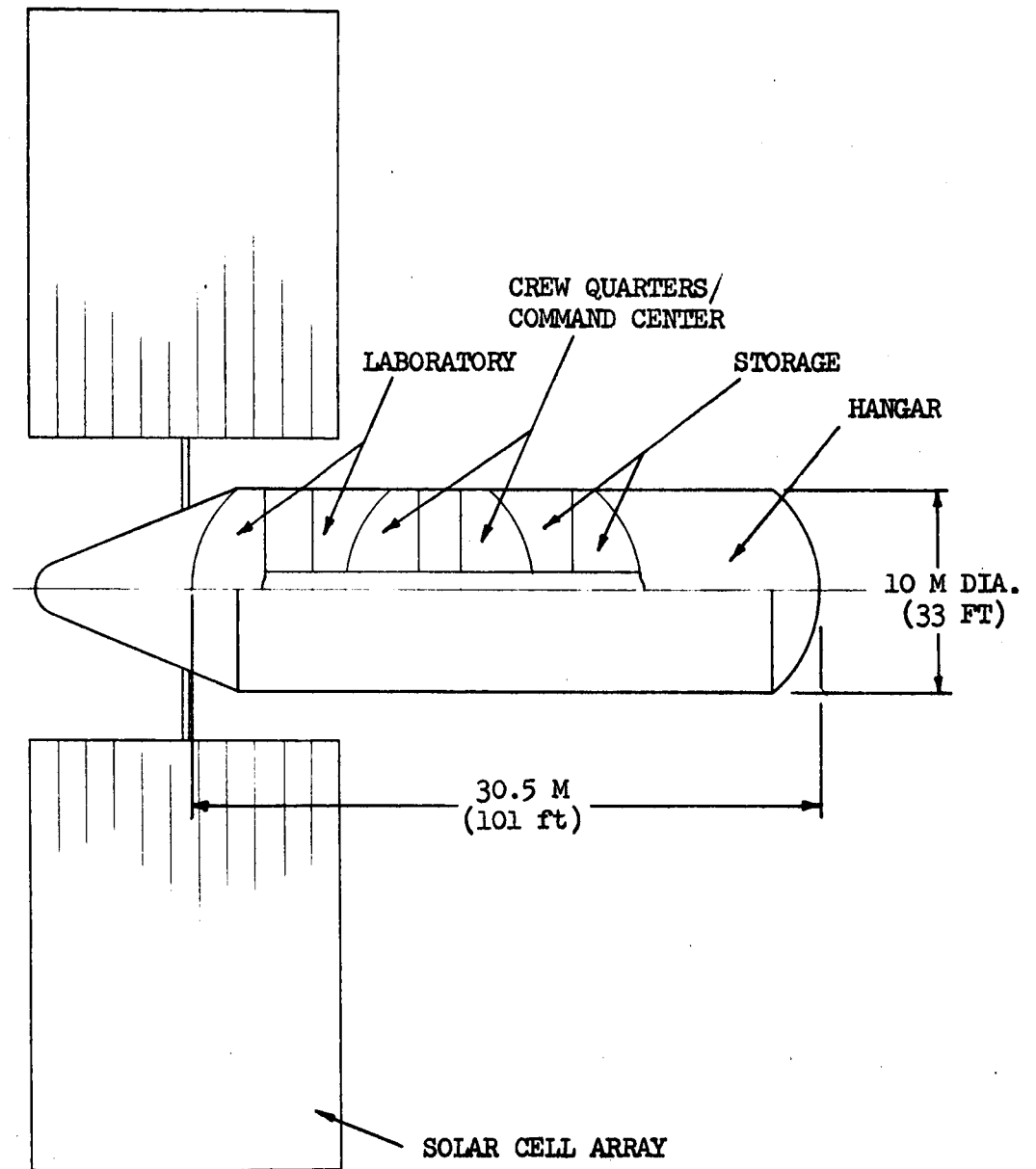
FIGURE 3-161: NASA MSC ZERO G SPACE STATION

resupplied at regular intervals by the use of routinely scheduled logistics vehicles. The addition of orbital launch operations equipment and orbital support vehicles to the space stations will transform any one of the space stations into a full-fledged Orbital Launch Support Facility with the capability to support any of the guideline missions.

4. CONCLUSIONS

In view of the many tasks to be performed in Orbital Launch Operations in support of the guideline missions, some form of support is required. This support may be supplied by either of two modes. One mode is by means of temporary vehicles staffed with a checkout crew, which dock with the Orbital Launch Vehicles and remain in orbit until launch following which the vehicles and checkout crew return to Earth. The second mode is by means of a permanent Orbital Launch Support Facility. A discussion of these modes and the relative economics and advantages of each may be found in Volume II.

Based on current knowledge of the numbers of personnel required and special equipment required for Orbital Launch Operations, the designs of the large manned space stations under study by NASA could, with some modifications, serve as an Orbital Launch Support Facility. This is not to say that such an Orbital Launch Support Facility could, at the same time, perform other jobs of an experimental or scientific nature since combinations of other jobs with orbital support functions have not been analyzed. The logistics and personnel (both in numbers and in training) requirements for such combinations of jobs become highly important in determining the feasibility of such arrangements.

There is not, at this time, a clear cut requirement for an orbital hangar for the guideline mission Orbital Launch Vehicles. The addition of such a hangar poses significant problems, especially if attached to the facility. A hangar, designed integrally with the Orbital Launch Support Facility, for the Orbital Support Equipment or logistics vehicles may be justified in view of the long orbital stay time; however, no analyses of this case has been performed in this study.

The use of nuclear systems in orbital launch operations imposes requirements for personnel shielding, facility or mission vehicle orientation and specific operational procedures. Repair and maintenance on nuclear propulsion engines results in extreme weight penalties for shielded facilities; the magnitude is such that it would probably require an additional Saturn V launch vehicle.

Cargo and personnel transfer between hard docked and separated vehicles is feasible by several means. Hard docked transfer of personnel is best done by ambulatory means. It is recommended that cargo transfer be accomplished by means of the handcarry method. The recommendation for remote transfer of both personnel and cargo is by the breeches buoy method. Pending further analysis, these methods are conditionally recommended at this time.

In the area of Orbital Support Vehicles, there are a number of tasks to be performed which require support vehicles such as the Orbital Support and Assembly Vehicle (OSAV) and a crew module for transport of personnel. Other spacecraft not specifically developed for Orbital Launch Operations may satisfy some of these tasks. These include vehicles such as the Gemini, Apollo, 6-man Modified Apollo (MODAP), 12-man ballistic or lifting vehicles, 10-ton Reuseable Orbital Carrier, Astronaut Maneuvering Unit, etc.

Logistics requirements for support of both the Orbital Launch Support Facility and the guideline missions may be satisfied by routine, periodic resupply flights using either the Saturn IB or the 10-ton Reuseable Orbital Carrier.

Evolutionary development of the Orbital Launch Support Facility is possible by one of two methods. One is to use a modified MORL as a building block and assemble it in clusters of two or four depending upon manpower requirements. Later orbital facilities may then be designed to incorporate the findings of the first MORL. An alternate and more logical approach is to proceed directly with a large space station/Orbital Launch Support Facility design with the capability for providing artificial gravity by means of rotation. Should the MORL program prove that artificial gravity is not required, then this facility would not have to be rotated. Later, larger Orbital Launch Support Facilities would then be designed to incorporate whichever type of gravity provision is determined to be necessary.

5. RECOMMENDATIONS FOR FURTHER STUDY

It is recommended that additional work be done in examination of methods of adapting large manned space stations to the role of an Orbital Launch Support Facility. In addition, independent Orbital Launch Support Facilities studies should be continued. The results of NASA sponsored space station studies should be fully utilized in this effort. More detailed knowledge of guideline mission subsystems should be obtained to permit better definition of support equipment.

The need for an orbital hangar should be examined further. If determined to be necessary, methods of providing a hangar should be studied in more detail.

The operational implications of nuclear systems should be studied further. A deeper penetration into methods of handling, servicing and repairing of "hot" nuclear engines should be conducted.

More work needs to be done in the area of orbital support vehicles. A better definition of the Orbital Support Assembly Vehicle and its role is required. Other support vehicles and their roles should be determined in more detail. Specific methods of implementing various orbital launch operations tasks should be examined.

6. REFERENCES

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APPENDIX A

SEQUENCE OF OPERATIONS AND EVENTS REQUIRED TO
LAUNCH GUIDELINE MISSION VEHICLES

This appendix contains a listing of the major operations broken down into a series of events for the supporting functions required in Earth orbit to prepare, checkout, and launch each of the guideline mission vehicles, as discussed in Section 4 of this volume. Major operations and/or events requiring a different method of execution with or without an OLSF have been identified and are presented for either condition.

The manner of accomplishing each operation and/or event, the man/machine tasks, the kinds of skills and number of personnel required, time requirements, etc., are presented in the Function and Task Analysis results (Appendices B, C, D, and E.).

The reader is cautioned that each major operation and its events breakdown are not necessarily directly comparable in magnitude -- either within a given mission sequence or when compared to different mission sequences. Whereas it is generally true that the greater the number of operations required to prepare a vehicle for orbital launch, the longer the time required, there is no direct ratio. For example, it does not necessarily hold true that it would require twice as long, nor would the magnitude of the effort necessarily be twice as great, to launch a given vehicle requiring 40 operations as compared to launching another vehicle requiring 20 operations. The first objective in listing these supporting operations was to be sure (within the extent of knowledge available) to describe all those operations required. The breakdown of each major operation is to some extent arbitrary. In any case, the Function and Task Analysis has treated each operation and event individually in estimating the required time, personnel, auxiliary equipment, etc.

It is pointed out that the sequences of this appendix were derived early in the study, and as such, may not be completely consistent with the later findings outlined in Volume II. However, these event sequences do provide a reasonable base on which to evaluate the required orbital support functions and to make estimations of manpower and equipment for the required support.

APPENDIX A.1

EVENTS BREAKDOWN OF MAJOR OPERATIONS - MARS FLYBY VEHICLE

Major Operation No.	Event	Description of Operations & Events
1		Launch Mars Flyby Vehicle to Earth orbit (manned by part of checkout crew)
	1	Launch to parking orbit
	2	**Separate and jettison fairing**
	3	Transfer to assembly orbit
	4	Activate vehicle guidance system
2a (w/o OLSF)		Launch Orbital Support Vehicle to Earth Orbit (manned by rest of checkout crew)
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
2b (with OLSF)		Transfer Orbital Support Vehicle to Mission Vehicle
	1	Transfer rest of checkout crew from OLSF to support vehicle.
	2	Separate support vehicle from OLSF.
	3	Transfer support vehicle to mission vehicle.
3		Rendezvous and Dock Orbital Support Vehicle with Mission Vehicle
	1	Perform rendezvous maneuver
	2	Dock support vehicle w/mission veh.
	3	Crew transfer as required for erection operations.
	4	Deactivate all RF equipment
	5	Deactivate required pyrotechnics
	6	Activate RF equipment
4		Perform Erection Operations on Mission Vehicle
	1	Initiate erection operations
	2	Position mission command module on spoke
	3	Rotate and position service module on spoke
	4	Extend spokes
	5	Lock spokes and modules in position
	6	Effect pressurization seals at fold-lines

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Major Operation No.	Event	Description of Operations & Events
	6(continued)	(a) Perform welding operations at foldlines.
	7	Reposition internal arrangement of command module.
		(a) Reposition displays and controls.
		(b) Reposition mission commanders restraint system.
	8	Assemble elevator in spoke assembly.
5		Perform checkout of Mission Vehicle
	1	Activate vehicle pressurization system.
	2	Activate vehicle primary electrical power system.
	3	Perform checkout of mission vehicle.
	4	Verify status of all systems - call for next payload.
6		Launch Propellant Tanker No. 1 to Earth Orbit (unmanned)
	1	Launch to parking orbit
	2	Separate launch fairing
	3	Transfer to assembly orbit
7		Rendezvous and Dock Propellant Tanker No. 1 to Mission Vehicle
	1	Perform rendezvous maneuver.
	2	Dock propellant tanker to mission propulsion module.
	3	Position propellant transfer lines
	4	Confirm status - call for next payload.
8		Launch Propellant Tanker No. 2 to Earth Orbit
	1	Launch to parking orbit
	2	Separate launch fairing
	3	Transfer to assembly orbit

Major Operation No.	Event	Description of Operations & Events
9		Rendezvous and Dock Propellant Tanker No. 2 to Mission Vehicle
	1	Perform rendezvous maneuver
	2	Dock propellant tanker to mission propulsion module.
	3	Position propellant transfer lines.
10		Perform Checkout of Mission Vehicle
	1	Activate all systems
	2	Perform and monitor checkout of mission vehicle.
	3	Complete vehicle checkout - verify vehicle ready for propellant transfer.
11		Perform Propellant Transfer from Propellant Tankers to Mission Vehicle Earth Escape Booster
	1	Initiate propellant transfer operation.
	2	Observe propellant transfer areas of possible leakage.
	3	Observe vent lines for proper venting.
	4	Monitor propellant mass transferred - terminate propellant transfer at pre-determined quantity.
	5	Terminate transfer operation.
	6	Verify status of vehicle and quantity of propellants.
12		Separate Propellant Tankers
	1	Separate tankers from mission vehicle.
	2	Position propellant tankers away from mission vehicle.
	3	Inspect propellant servicing areas.
	4	Conduct visual inspection of structure for possible damage incurred during separation of tanker modules.
13		Perform Checkout of Mission Vehicle
	1	Deactivate all RF systems.
	2	Activate pyrotechnic systems.
	3	Activate all required systems.
	4	Confirm ephemeris data.
	5	Conduct checkout of mission vehicle.

Major Operation No.	Event	Description of Operations & Events
13 (continued)	6	Complete checkout - confirm status of vehicle.
	7	Position support vehicle for servicing mission vehicle.
	8	Connect service lines from support vehicle to mission vehicle.
	9	Perform service functions - top off all systems as required.
	10	**Confirm status** of mission vehicle for orbit launch. Verify vehicle ready for mission crew.
14		Separate Orbital Support Vehicle - Transfer to Parking Orbit
	1	Separate support vehicle with majority of checkout crew aboard from mission vehicle.
	2	Transfer support vehicle to parking orbit.
		Note: Support vehicle waits in orbit for launch of mission vehicle. The parking orbit will be such that the support vehicle can provide television coverage of the orbit launch. Also, the support vehicle must standby to effect possible emergency repairs prior to launch.
15		Launch Mission Crew Carrier to Earth Orbit (manned by mission crew)
	1	Launch to parking orbit
	2	Separate and jettison fairing and launch escape propulsion.
	3	Transfer to assembly orbit.
	4	Separate payload and boost stage.
16		Rendezvous and Dock Mission Crew Carrier with Mission Vehicle
	1	Perform rendezvous maneuver.
	2	Dock Mission Crew Carrier with Mission Vehicle.
	3	Mission crew transfer to mission vehicle.
	4	Final part of checkout crew transfer to mission crew carrier.

Major Operation No.	Event	Description of Operations & Events
17		Separate Mission Crew Carrier and Transfer to Parking Orbit
	1	Separate Mission Crew Carrier (manned by part of checkout crew) from mission vehicle.
	2	Transfer mission crew carrier to parking orbit. <u>Note</u>: Mission Crew Carrier waits in orbit for launch of mission vehicle. The parking orbit will be such that the support vehicle can provide television coverage of the orbit launch. The mission crew carrier must also standby to effect possible emergency repairs prior to launch.
18		Mission Crew Conduct Mission Readiness Test
	1	Perform mission readiness test - checkout all systems operation - confirm status.
	2	Perform simulated countdown and launch.
	3	Confirm ephemeris data and vehicle attitude for launch.
	4	Confirm vehicle ready for countdown.
19		Conduct Pre-launch Operations and Countdown
	1	Initiate pre-launch operations
	2	Verify status of vehicle systems
	3	Monitor bio-med. data: verify mission personnel ready.
	4	Initiate simulated countdown.
	5	Complete pre-launch operations and countdown.
	6	Confirm vehicle status.
	7	Establish vehicle ready for final countdown.
20		Initiate Final Countdown
	1	Start countdown of mission vehicle.
	2	Confirm relative position of Support Vehicle and Mission Crew Carrier.
	3	Complete all countdown up to automatic sequence portion.

Major Operation No.	Event	Description of Operations & Events
20 (continued)	4	Initiate countdown "hold" – synchronize launch time with automatic launch count.
	5	Initiate automatic countdown sequence.
21		Mission Vehicle Launch
	1	Initiate launch sequence.
	2	Launch from orbit.
	3	Support vehicles monitor launch.
	4	Support vehicle and mission crew carrier return to station.

EVENTS BREAKDOWN OF MAJOR OPERATIONS - MARS CAPTURE VEHICLE

Major Operation No.	Event	Description of Operations & Events
1		Launch M-3 and M-4 Stages and Life Support Section (LSS) to Earth Orbit. Note: Manned by part of checkout crew.
	1	Launch to parking orbit
	2	Separate and jettison fairing and launch escape propulsion.
	3	Transfer to assembly orbit.
	4	Separate payload and boost stage.
	5	Separate launch structure and adaptor.
	6	Activate navigation and guidance systems.
2		Conduct Checkout of M-3 and M-4 Stages and LSS
	1	Reposition re-entry vehicle for mission.
	2	Crew transfer to LSS.
	3	Deactivate required systems.
	4	Deactivate and/or remove required pyrotechnics.
	5	Store pyrotechnics as required.
	6	Activate required systems.
	7	Perform checkout of re-entry vehicle
	8	Verify status of re-entry vehicle - call for next payload.
3a (w/o OLSF)		Launch Orbital Support Vehicle No. 1 (manned by rest of checkout crew)
	1	Launch to parking orbit.
	2	Separate and jettison fairing and launch escape propulsion.
	3	Transfer to assembly orbit.
3b (with OLSF)		Transfer Orbital Support Vehicle to LSS (manned by rest of checkout crew)
	1	Transfer checkout crew from OLSF to support vehicle.
	2	Separate support vehicle from OLSF.
	3	Transfer support vehicle to LSS.
4		Rendezvous and Dock Orbital Support Vehicle with LSS
	1	Perform rendezvous maneuver

Major Operation No.	Event	Description of Operations & Events
4 (continued)	2	Dock support vehicle to LSS section
	3	Crew transfer as required for mission vehicle checkout operations.
	4	Confirm mission vehicle status - call for next payload.
5		Launch M-2 Stage Payload to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
6		Rendezvous and Dock M-2 Stage Payload to M-3 Stage
	1	Perform rendezvous maneuver.
	2	Align M-2 Stage to M-3 Stage.
	3	Dock M-2 Stage to M-3 Stage.
	4	Confirm status of mission vehicle
	5	Separate M-2 Stage payload and transtage.
7		Assembly M-2 Stage to M-3 Stage
	1	Checkout crew transfer as required for assembly operations.
	2	Confirm alignment of electrical connectors at interface of M-2 and M-3 Stages.
	3	Confirm alignment of plumbing connectors at interface of M-2 and M-3 stages.
	4	Complete assembly operations. Secure mechanical attachments at interface.
	5	Install separation system. Note: Pyrotechnic system deactivated and/or grounded.
	6	Confirm assembly operations complete.
8		Perform Checkout of M-2 Stage
	1	Activate mission vehicle checkout equipment.
	2	Perform checkout of mission vehicle systems.
	3	Confirm status of mission vehicle systems - call for next payload.

Major Operation No.	Event	Description of Operations & Events
9		Launch M-1B Stage Payload to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
10		Rendezvous and Dock M-1B Stage Payload to M-2 Stage
	1	Perform rendezvous maneuver
	2	Align M-1B Stage to M-2 Stage
	3	Dock M-1B Stage to M-2 Stage
	4	Confirm status of mission vehicle
	5	Separate M-1B stage and transtage
11		Assemble M-1B Stage to M-2 Stage
	1	Checkout crew transfer as required for assembly operations
	2	Confirm alignment of electrical connectors at interface of M-1B & M-2 Stages
	3	Confirm alignment of plumbing connectors at interface of M-2 & M-3 Stages
	4	Complete assembly operations. Secure mechanical attachments at interface.
	5	Install separation system. Note: Pyrotechnic system deactivated and/or grounded.
	6	Confirm assembly operations complete.
12		Perform Checkout of M-1B Stage
	1	Activate mission vehicle checkout equipment
	2	Perform checkout of mission vehicle systems
	3	Confirm status of mission vehicle systems - call for next payload.
13		Launch M-1A Stage Payload to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
14		Rendezvous and Dock M-1A Stage Payload to M-1B Stage
	1	Perform rendezvous maneuver
	2	Align M-1A Stage to M-1B Stage

Major Operation No.	Event	Description of Operations & Events
14 (continued)	3	Dock M-1A Stage to M-1B Stage
	4	Confirm status of mission vehicle
	5	Separate M-1A stage and transtage
15		Assemble M-1A Stage to M-1B Stage
	1	Checkout crew transfer as required for assembly operations.
	2	Confirm alignment of electrical connectors at interface of M-1B and M-1A stages.
	3	Confirm alignment of plumbing connectors at interface of M-2 & M-3 Stages.
	4	Complete assembly operations. Secure mechanical attachments at interface.
	5	Confirm assembly operations complete.
16		Perform Major Checkout of Complete Mission Vehicle
	1	Activate mission vehicle checkout equipment
	2	Perform major checkout of mission vehicle systems
	3	Confirm status of mission vehicle systems
	4	Establish logistics requirements - call for next orbital support vehicle
17a (w/o OLSF)		Launch Orbital Support Vehicle No. 2
	1	Launch to parking orbit
	2	Separate and jettison launch fairing
	3	Transfer to assembly orbit
17b (with OLSF)		Transfer Orbital Support Vehicle for Resupply
	1	Transfer support vehicle from LSS to OLSF
	2	Rendezvous and dock support vehicle with OLSF
	3	Transfer logistic requirements for mission vehicle from OLSF to support vehicle
	4	Transfer support vehicle from OLSF to LSS

Major Operation No.	Event	Description of Operations & Events
18		Rendezvous and Dock Orbital Support Vehicle to LSS
	1	Perform rendezvous maneuver
	2	Dock support vehicle to LSS
	3	Transfer logistics requirements from support vehicle to LSS
	4	Confirm mission vehicle status - ready for service functions
19		Perform Service Functions - Refurbish Mission Vehicle Systems
	1	Connect service lines
	2	Service systems as required
	3	Re-establish mission spares level
	4	Perform routine maintenance items
	5a (w/o OLSF)	Establish routine duty cycle and maintenance shifts.
	5b (with OLSF)	Return personnel to OLSF as applicable. Partial manning of OLV for routine maintenance. Return support vehicle to OLV when next payload is launched.
	6	When applicable, confirm mission vehicle status acceptable for next payload.
20		Launch Propellant Tanker No. 1 to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison launch fairing
	3	Transfer to assembly orbit
21		Rendezvous and Dock Propellant Tanker No. 1 with Mission Vehicle
	1	Perform rendezvous maneuver
	2	Dock propellant tanker to mission propulsion module.
22		Position Propellant Tank Module and Connect Service Lines
	1	Align propellant tank module as required.
	2	Remove covers from propellant transfer areas
	3	Connect propellant transfer lines
	4	Call for next payload

Major Operation No.	Event	Description of Operations & Events
23		Launch Propellant Tanker No. 2 to Earth Orbit
	o	Events same as for Major Operation No. 20
24		Rendezvous and Dock Propellant Tanker No. 2 with Mission Vehicle
	o	Events same as for Major Operation No. 21
25		Position Propellant Tank Module and Connect Service Lines
	o	Events same as for Major Operation No. 22
26		Launch Propellant Tanker No. 3 to Earth Orbit
	o	Events same as for Major Operation No. 20
27		Rendezvous and Dock Propellant Tanker No. 3 with Mission Vehicle
	o	Events same as for Major Operation No. 21
28		Position Propellant Tank Module and Connect Service Lines
	o	Events same as for Major Operation No. 22
29		Perform Checkout of Mission Vehicle
	1	Activate all systems
	2	Perform and monitor checkout of OLV
	3	Complete mission vehicle checkout - verify mission vehicle ready for propellant transfer
30		Perform Propellant Transfer Operation
	1	Initiate propellant transfer operation
	2	Observe propellant transfer areas for possible leakage
	3	Observe vent lines for proper venting

Major Operation No.	Event	Description of Operations & Events
30 (continued)	4	Monitor propellant mass transferred-terminate propellant transfer at predetermined quantity
	5	Terminate transfer operation
	6	Verify status of mission vehicle and quantity of propellants
31		Separate Propellant Tankers from OLV
	1	Separate propellant tankers
	2	Position tankers away from OLV
	3	Inspect propellant servicing areas for security
	4	Conduct visual inspection of structure for any possible damage incurred during separation of propellant tanker modules
32		Perform Checkout of OLV
	1	Deactivate all RF systems
	2	Activate all pyrotechnic systems
	3	Activate all required systems
	4	Conduct checkout of OLV
	5	Complete checkout of OLV - establish logistics requirements for OLV
33a (w/o OLSF)		Launch Orbital Support Vehicle No. 3 to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison launch fairing
	3	Transfer to assembly orbit
33b (with OLSF)		Transfer Orbital Support Vehicle from LSS to OLSF
	1	Transfer support vehicle from LSS to OLSF
	2	Rendezvous and dock support vehicle with OLSF
	3	Transfer logistics requirements for mission vehicle from OLSF to support vehicle
	4	Transfer support vehicle from OLSF to LSS

Major Operation No.	Event	Description of Operations & Events
34		Rendezvous and Dock Orbital Support Vehicle to LSS
	1	Perform rendezvous maneuver
	2	Dock support vehicle to LSS
	3	Transfer logistics requirements from support vehicle to LSS
	4	Confirm mission vehicle ready for service
35		Perform Service Functions - Refurbish Mission Vehicle
	1	Connect service lines
	2	Re-establish mission spares level
	3	Complete routine maintenance checks
	4	Confirm mission vehicle ready for mission crew.
36		Launch Mission Crew Carrier - Manned by Mission Crew
	1	Launch to parking orbit
	2	Separate and jettison fairing and launch escape propulsion.
	3	Transfer to assembly orbit
	4	Separate payload and boost stage
37		Rendezvous and Dock Mission Crew Carrier with LSS
	1	Perform rendezvous maneuver
	2	Dock mission crew carrier with mission vehicle
	3	Mission crew transfer to mission vehicle
	4	Part of checkout crew transfer to mission crew carrier
	5	Complete service functions on all OLV systems
	6	All remaining checkout crew transfer to support vehicles
38		Separate Orbital Support Vehicles No. 1, 2, and 3 and Mission Crew Carrier (manned by Checkout Crew)
	1	Separate support vehicles from mission vehicle
	2	Transfer to parking orbit

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Major Operation No.	Event	Description of Operations & Events
39		Transfer Orbital Support Vehicles and Mission Crew Carrier to Parking Orbit
	1	Transfer vehicles to parking orbit. Note: Mission Crew Carrier waits in orbit for launch of OLV. The parking orbit will be such that the support vehicle can provide television coverage of the orbit launch.
40		Mission Crew Conduct Mission Readiness Test
	1	Perform mission readiness test - checkout all systems operation - confirm status
	2	Perform simulated countdown and launch
	3	Confirm ephemeris data and mission vehicle attitude for launch
	4	Confirm mission vehicle ready for countdown.
41		Conduct Pre-Launch Operations and Countdown
	1	Initiate pre-launch operations
	2	Verify status of mission vehicle systems
	3	Initiate simulated countdown
	4	Complete pre-launch operations & countdown
	5	Confirm mission vehicle status
	6	Establish mission vehicle ready for final countdown
42		Initiate final countdown
	1	Initiate countdown
	2	Complete all countdown up to automatic sequence portion.
	3	Initiate countdown "hold" - synchronize launch time with automatic launch count.
	4	Initiate automatic countdown sequence
	5	Confirm relative position of support vehicles
43		Mars Capture Mission - Launch
	1	Initiate launch sequence
	2	Launch mission vehicle from earth orbit

Major Operation No.	Event	Description of Operations & Events
43 (continued)	3	Support vehicles monitor launch and confirm injection
44		Orbital Support Vehicles and Mission Crew Carrier Return to Station
	1a (w/o OLSF)	Return to Earth.
	1b (with OLSF)	Support vehicle return to OLSF. Mission crew carrier return to Earth.

EVENTS BREAKDOWN OF MAJOR OPERATIONS - LUNAR FERRY

Major Operation No.	Event	Description of Operations & Events
1		Launch Nuclear Propulsion Module and Lunar Ferry Command Module to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
	4	Separate payload and boost stage
	5	Separate launch structure and adapter
	6	Activate Ferry guidance system.
2a (w/o OLSF)		Launch Orbital Support Vehicle (with Checkout Crew) to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Separate payload and boost stage
	4	Transfer support vehicle to assembly orbit.
2b (with OLSF)		Transfer Orbital Support Vehicle (with Checkout Crew) to Lunar Ferry.
	1	Transfer checkout crew from OLSF to support vehicle.
	2	Separate support vehicle from OLSF.
	3	Transfer support vehicle from OLSF to Lunar Ferry command module.
3		Rendezvous and Dock Support Vehicle with Lunar Ferry Command Module
	1	Perform rendezvous maneuver
	2	Dock support vehicle with Lunar Ferry command module
	3	Crew transfer from support vehicle to Lunar Ferry command module
	4	Perform checkout of life support and electrical power systems
	5	Deactivate all RF equipment
	6	Deactivate destruct systems
	7	Exit Lunar Ferry command module (as required)
	8	Remove pyrotechnic devices
	9	Remove destruct unit from nuclear engine
	10	Store pyrotechnics and destruct unit

Major Operation No.	Event	Description of Operations & Events
3 (continued)	11	Install fuses in places of pyrotechnics.
	12	Connect servicing lines from support vehicle to Lunar Ferry command module
	13	Perform service operations
	14	Disconnect service lines
	15	Activate RF systems - confirm status
	16	Replace routine replacement items (if required)

        (a) Guidance equipment
        (b) Reaction control
             propellant systems

Major Operation No.	Event	Description of Operations & Events
4		Perform Checkout of Nuclear Propulsion Module and Lunar Ferry Command Module
	1	Conduct visual inspection of external structure
	2	Conduct complete checkout of mission vehicle systems
	3	Verify all systems status - establish replacement items required to bring mission vehicle status to mission readiness condition.
	4	Deactivate non-essential systems.
	5	Call for next vehicle from Earth base.
	6	Reposition support vehicle away from primary docking fixture.
5		Launch Mission Crew and Passenger Carrier, Lunar Cargo Module No. 1 and Propellant Tanker Module No. 1 to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing and launch escape propulsion as required
	3	Transfer to assembly orbit
	4	Separate payload and boost stage
6		Rendezvous and Dock with Lunar Ferry Command Module
	1	Perform rendezvous maneuver
	2	Dock Mission Crew Carrier, Lunar Cargo Module No. 1 and Propellant Tanker Module No. 1 to Lunar Ferry command module.

Major Operation No.	Event	Description of Operations & Events
6 (continued)	3	Transfer personnel and handcarry cargo (if applicable) from carrier to Lunar Ferry command module.
	4	Deactivate all RF equipment.
	5	Deactivate pyrotechnic devices on Mission Crew and Passenger Carrier, Lunar Cargo Module No. 1 and Propellant Tanker Module No. 1.
	6	Store pyrotechnic devices
	7	Activate required systems
	8	Remove covers from propellant servicing areas of propellant tanker No. 1 and propulsion module.
	9	Verify mission vehicle ready for payload positioning.
7		Position Propellant Tanker Module No. 1 and Lunar Cargo Module No. 1 on Nuclear Propulsion Module
	1	Execute payload turn around.
	2	Position front of propellant tank No. 1 adjacent to propulsion module
	3	Separate propellant tanker No. 1 from cargo module No. 1
	4	Position propellant tanker No. 1 parallel with propulsion module and attach required structure.
	5	Confirm alignment of propellant transfer lines between propellant tanker No. 1 and propulsion module.
	6	Continue rotation and positioning of lunar cargo module No. 1.
	7	Position cargo module No. 1 in front of propulsion module.
	8	Retract booms - confirm positioning of cargo module No. 1 on propulsion module.
	9	Attach cargo module No. 1 to propulsion module.
	10	Separate mission crew and passenger carrier No. 1 from cargo module No.1
	11	Extend booms and rotate carrier and Lunar Ferry command module.
8		Transfer Mission Crew and Passenger Carrier No. 1 to Parking Orbit
	1	Transfer personnel (as required) from Lunar Ferry command module to carrier.

Major Operations No.	Event	Description of Operations & Events
8 (continued)	2	Install pyrotechnics (as required) on carrier.
	3	Verify carrier status acceptable for orbital stay.
	4	Separate personnel carrier from Lunar Ferry command module.
	5	Transfer carrier to parking orbit. Note: Mission Crew and Passenger Carrier waits in orbit for return of Lunar Ferry. The parking orbit will be such that the carrier can provide television coverage of orbit launch of Lunar Ferry. If Lunar Ferry command module does not have Earth re-entry capability, this carrier must also standby for personnel rescue.
	6	Repair and or refurbish Lunar Ferry Command Module systems as required.
	7	Confirm status of mission vehicle and establish spare parts requirements.
	8	Deactivate non-essential systems.
	9	Call for next vehicle from Earth base.
9		Launch Mission Crew and Passenger Carrier No. 2, Lunar Cargo Module No. 2 and Propellant Tanker Module No. 2 to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing and launch escape propulsion as required.
	3	Transfer to assembly orbit.
	4	Separate payload and boost stage.
10		Rendezvous and Dock No. 2 ELV Payload with Lunar Ferry Command Module
	1	Perform rendezvous maneuver
	2	Dock Mission Crew and Passenger Carrier, Lunar Cargo Module No. 2 and Propellant Tanker Module No. 2 to Lunar Ferry command module.
	3	Transfer personnel and handcarry cargo (if applicable) from carrier to Lunar Ferry command module.
	4	Deactivate all RF equipment.
	5	Deactivate pyrotechnic devices on Mission Crew and Passenger Carrier, Lunar Cargo Module No. 1 and Propellant Tanker Module No. 1.

Major Operation No.	Event	Description of Operations & Events
10 (continued)	6	Store pyrotechnic devices.
	7	Activate required systems.
	8	Remove covers from propellant servicing areas of propellant tanker and propulsion module.
	9	Verify mission vehicle ready for payload positioning.
11		Position Propellant Tanker Module No. 1 and Lunar Cargo Module No. 1 on Nuclear Propulsion Module
	1	Execute payload turn around.
	2	Position front of propellant tank No. 2 adjacent to propulsion module.
	3	Separate propellant tanker No. 2 from cargo module.
	4	Position propellant tanker No.2 parallel with propulsion module and attach required structure.
	5	Confirm alignment of propellant transfer lines between propellant tanker No. 2 and propulsion module.
	6	Continue rotation and positioning of lunar cargo module No. 2.
	7	Position cargo module No. 2 in front of cargo module No. 1
	8	Retract booms - confirm positioning of cargo module No. 2 on cargo module No. 1.
	9	Attach cargo module No. 2 to cargo module No. 1.
	10	Separate carrier from cargo module No. 2.
	11	Extend booms, rotate carrier and Lunar Ferry command module.
	12	Position Lunar Ferry command module on cargo modules.
12		Transfer Mission Crew and Passenger Carrier No. 2 to Parking Orbit
	1	Transfer personnel (as required) from Lunar Ferry command module to carrier.
	2	Install pyrotechnics (as required) on carrier.
	3	Verify carrier status acceptable for orbital stay.
	4	Separate carrier from Lunar Ferry command module.
	5	Transfer carrier to parking orbit.

Major Operation No.	Event	Description of Operations & Events
12 (continued)		Note: Mission Crew and Passenger Carrier waits in orbit for return of Lunar Ferry. The parking orbit will be such that the carrier can provide television coverage of orbit launch of Lunar Ferry. If Lunar Ferry command module does not have Earth re-entry capability, this carrier must standby for personnel rescue.
	6	Repair and/or refurbish Lunar Ferry command module systems as required.
	7	Confirm status of mission vehicle.
13		Perform Checkout of Lunar Ferry
	1	Activate all systems
	2	Perform and monitor checkout of Lunar Ferry systems.
	3	Complete mission vehicle checkout - verify mission vehicle ready for propellant transfer.
14		Perform Propellant Transfer from Propellant Tankers to Nuclear Propulsion Module
	1	Initiate propellant transfer operation.
	2	Observe propellant transfer areas for possible leakage.
	3	Observe vent lines for proper venting
	4	Monitor propellant mass transferred - terminate transfer at pre-determined quantity (this quantity dependent upon mission velocity requirements).
	5	Terminate transfer
	6	Verify status of mission vehicle and quantity of propellants.
15		Separate Propellant Tanker Modules from Nuclear Propulsion Module
	1	Separate propellant tanker modules away from nuclear propulsion module.
	2	Position tanker modules away from nuclear propulsion module.
	3	Inspect propellant servicing areas - replace servicing area covers.
	4	Conduct visual inspection of structure for possible damage incurred during separation of tanker modules.

Major Operation No.	Event	Description of Operations & Events
16		Perform Checkout of Lunar Ferry
	1	Turn-off all RF and other non-essential systems.
	2	Install pyrotechnics, shaped charges, and destruct units as required on Lunar Ferry.
	3	Store pyrotechnics in Lunar Ferry (pyrotechnics to be utilized in lunar orbit).
	4	Activate all systems.
	5	Confirm ephemeris data.
	6	Conduct checkout of mission vehicle systems.
	7	Complete checkout - confirm status of mission vehicle.
	8	Position support vehicle to primary docking structure.
	9	Connect service lines from support vehicle to Lunar Ferry command module.
	10	Perform service functions - top off all systems as required.
	11	Confirm status of mission vehicle for orbit launch.
	12	Install pyrotechnics in support vehicle.
	13	Checkout crew transfer from Lunar Ferry command module to support veh.
17		Separate Orbital Support Vehicle (with Checkout Crew) and Transfer to Parking Orbit
	1	Verify support vehicle status acceptable.
	2	Separate support vehicle from Lunar Ferry command module.
	3	Transfer support vehicle to parking orbit. Note: Orbital support vehicle waits in orbit for return of Lunar Ferry. The parking orbit will be such that the support vehicle can provide television coverage of orbit launch. Also, the support vehicle must stand-by to effect possible emergency repairs prior to launch.

Major Operation No.	Event	Description of Operations & Events
18		Mission Crew Perform Mission Readiness Test
	1	Perform mission readiness tests - checkout all systems operation - confirm status.
	2	Perform simulated countdown and launch - confirm status and launch timing.
	3	Confirm ephemeris data and mission vehicle attitude for launch.
	4	Confirm vehicle ready for countdown.
19		Conduct Pre-Launch Operations and Countdown
	1	Initiate pre-launch operations.
	2	Verify status of vehicle systems.
	3	Monitor bio-med. data - verify all personnel ready.
	4	Initiate simulated countdown.
	5	Complete pre-launch operations and countdown.
	6	Confirm mission vehicle status.
	7	Establish mission vehicle ready for final countdown.
20		Initiate Final Countdown
	1	Start countdown of Lunar Ferry
	2	Confirm relative position of carriers No. 1 and 2, and support vehicle. Note: This relative position must be compatible with television coverage requirements, and separation distances for protection from nuclear radiation during overflight and/or flyby.
	3	Complete all countdown up to automatic sequence portion.
	4	Initiate countdown "hold" - synchronize launch time with automatic launch count
	5	Initiate automatic countdown sequence
21		Lunar Ferry Launch
	1	Initiate launch sequence - engine start and thrust buildup.
	2	Monitor orbit launch sequence - confirm translunar injection.

Major Operation No.	Event	Description of Operations & Events
21 (continued)	3a (w/o OLSF)	Carriers No. 1 and 2, and support vehicle submit to station keeping requirements and wait for return of Lunar Ferry.
	3b (with OLSF)	Carrier No. 1 and No. 2, and support vehicle transfer to OLSF. Crew waits at OLSF for return of Lunar Ferry.
22		Lunar Ferry Return to Earth Orbit
	1	Inject into Earth orbit
	2	Deactivate non-essential systems
	3	Activate rendezvous system
	4	When engine thrust has decayed - verify vehicle ready for rendezvous operations.
23		Transfer to Assembly Orbit
		Note: If OLSF is assumed the Lunar Ferry will transfer to OLSF orbit. With no OLSF, the Lunar Ferry will not transfer, but will inject directly to the assembly orbit.
	1	Perform transfer maneuver.
	2	Position Lunar Ferry for rendezvous operations.
24		Orbital Support Vehicle (with checkout crew), Rendezvous and Dock with Lunar Ferry Command Module
	1	Transfer from parking orbit (or OLSF) to assembly orbit.
	2	Perform rendezvous maneuver.
	3	Dock support vehicle to Lunar Ferry command module.
	4	Deactivate all RF equipments.
	5	Deactivate pyrotechnics, shaped charges and destruct units.
	6	Remove pyrotechnics and store.
	7	Activate required systems.
	8	Position support vehicle away from primary docking assembly.
	9	Call carrier No. 1 for crew transfer.

Major Operation No.	Event	Description of Operations & Events
25		Mission Crew and Passenger Carrier No. 1 Rendezvous and Dock with Lunar Ferry Command Module
	1	Transfer from parking orbit (or OLSF) to assembly orbit.
	2	Perform rendezvous maneuver.
	3	Dock carrier to command module
	4	Transfer personnel from Lunar Ferry command module to carrier No. 1.
	5	Complete personnel transfer and verify carrier No. 1 ready for separation and re-entry.
26		Separate Mission Crew and Passenger Carrier No. 1 and Transfer for Return to Earth
	1	Separate carrier No. 2
	2	Transfer to parking orbit for re-entry.
	3	Call carrier No. 2 for crew transfer.
27		Mission Crew and Passenger Carrier No. 2 Rendezvous and Dock with Lunar Ferry Command Module
	1	Transfer from parking orbit (or OLSF) to assembly orbit.
	2	Perform rendezvous maneuver.
	3	Dock carrier No. 2 to command module
	4	Transfer personnel from Lunar Ferry command module to carrier No. 2.
	5	Complete personnel transfer and verify carrier No. 2 ready for separation and re-entry.
28		Separate Mission Crew and Passenger Carrier No. 2 and Transfer for Return to Earth
	1	Separate carrier No. 2
	2	Transfer to parking orbit for re-entry.
29		Perform Post-Flight Checkout of Lunar Ferry
	1	Repair defective items noted by mission crew.

Major Operation No.	Event	Description of Operations & Events
29 (continued)	2	Perform visual check of nuclear core (performed with remote T.V. unit)
	3	Perform neutron pulse check of nuclear engine
	4	Conduct complete checkout of mission vehicle systems
	5	Verify all systems status - establish spares requirements (with Earth facilities) for next Lunar Ferry cycle.
	6	Deactivate non-essential systems.
	7	Rotate support vehicle to primary docking structure.
	8	Verify status of support vehicle.
	9	Checkout crew transfer to support vehicle.
30		Separate Support Vehicle and Transfer for Return to Station
	1	Separate support vehicle from Lunar Ferry command module. Transfer to parking orbit for return to Earth base or OLSF.

APPENDIX A.4

EVENTS BREAKDOWN OF MAJOR OPERATIONS - MARS LANDING CONVOY

Major Operation No.	Event	Description of Operations & Events
1		Launch Life Support Section (LSS) to Earth Orbit. Note: Manned by Checkout Crew
	1	Launch to parking orbit
	2	Separate and jettison fairing and escape propulsion
	3	Transfer to assembly orbit
	4	Separate payload and boost stage
	5	Separate launch structure and adaptor
	6	Activate LSS stabilization system
2		Conduct Checkout of Life Support Section
	1	Reposition re-entry vehicle for entry into LSS.
	2	Crew transfer to LSS
	3	Deactivate required systems
	4	Deactivate and/or remove non-essential pyrotechnics
	5	Store pyrotechnics as required
	6	Activate required systems
	7	Perform checkout of LSS
	8	Complete checkout, call for next payload
3a (w/o OLSF)		Launch Orbital Support Vehicle to Earth Orbit. Note: Manned by Checkout Crew
	1	Launch to parking orbit
	2	Separate and jettison fairing and escape propulsion
	3	Transfer to assembly orbit
	4	Separate payload and boost stage
3b (with OLSF)		Transfer Orbital Support Vehicle to LSS
	1	Transfer checkout crew from OLSF to support vehicle
	2	Separate support vehicle from OLSF
	3	Transfer support vehicle to LSS
4		Rendezvous and Dock Orbital Support Vehicle with LSS
	1	Perform rendezvous maneuver

Major Operation No.	Event	Description of Operations & Events
4 (continued)	2	Dock support vehicle to LSS
	3	Crew transfer as required for mission vehicle checkout operations. Confirm mission vehicle status - call for next payload
5		Launch Crew Vehicle Propulsion Module to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
	4	Separate payload and boost stage
6		Rendezvous and Dock Life Support Section to Crew Vehicle Propulsion Module
	1	Perform rendezvous maneuver
	2	Align LSS to crew vehicle propulsion module.
	3	Dock LSS to crew vehicle propulsion module.
7		Assemble LSS to Crew Vehicle Propulsion Module
	1	Confirm alignment of electrical connectors
	2	Confirm alignment of fluid connectors
	3	Complete assembly operations. Secure mechanical connectors
	4	Install separation system at separation plane
	5	Confirm assembly operations complete. Call for next payload.
8		Launch Service Vehicle "A" to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
	4	Position vehicle in assembly orbit
	5	Separate payload and boost stage
9		Launch Service Vehicle "B" to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit

Major Operation No.	Event	Description of Operations & Events
9 (continued)	4	Position vehicle in assembly orbit
	5	Separate payload and boost stage
10		Checkout Crew Performs Inspection of Mission Crew Vehicle
	1	Activate all mission vehicle checkout equipment
	2	Perform checkout of all mission vehicle systems
	3	Perform visual inspection of mission vehicle structure
	4	Confirm status of mission vehicle. Establish spares requirement.
11		Checkout Crew Transfers to Service Vehicle "A"
	1	Checkout crew transfers to support vehicle
	2	Separate support vehicle from Mission Crew Vehicle
	3	Transfer to Service Vehicle "A"
	4	Dock support vehicle to Service Vehicle "A"
	5	Checkout crew transfer to Service Vehicle "A"
12		Checkout Crew Performs Checkout of Service Vehicle "A"
	1	Activate all mission vehicle systems
	2	Perform checkout of all mission vehicle systems
	3	Perform checkout of all auxiliary mission vehicles
	4	Perform visual inspection of mission vehicle structure
	5	Confirm mission vehicle status. Establish spares requirement to re-establish mission spares level.
13		Checkout Crew Transfers to Service Vehicle "B"
	1	Checkout crew transfers to support vehicle
	2	Separate support vehicle from Service Vehicle "A"
	3	Transfer to Service Vehicle "B"
	4	Dock support vehicle to Service Vehicle "B"

Major Operation No.	Event	Description of Operations & Events
13 (continued)	5	Checkout Crew transfers to Service Vehicle.
14		Checkout Crew Performs Checkout of Service Vehicle "B"
	1	Activate all mission vehicle systems
	2	Perform checkout of all mission vehicle systems
	3	Perform checkout of all auxiliary mission vehicles
	4	Perform visual inspection of mission vehicle structure
	5	Confirm mission vehicle status. Establish spares requirement. Call for support vehicle.
15a (w/o OLSF)		Launch Orbital Support Vehicle
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit
15b (with OLSF)		Transfer Orbital Support Vehicle for Resupply
	1	Transfer support vehicle from Service Vehicle "B" to OLSF for resupply.
	2	Rendezvous and dock support vehicle with OLSF
	3	Transfer logistics requirements, for mission vehicles, from OLSF to support vehicle.
	4	Transfer support vehicle from OLSF to Service Vehicle "B"
16		Rendezvous and Dock Orbital Support Vehicle with Service Vehicle "B"
	1	Perform rendezvous maneuver
	2	Dock support vehicle to Service Vehicle "B"
	3	Transfer logistics requirements to Service Vehicle "B"
17		Service Vehicle "B" Repair and Refurbishment
	1	Perform repair functions on Service Vehicle "B"

Major Operation No.	Event	Description of Operations & Events
17 (continued)	2	Refurbish expendable systems of Service Vehicle "B"
	3	Re-establish spares level in Service Vehicle "B"
18		Recheck Service Vehicle "B"
	1	Perform checkout of Service Vehicle "B"
	2	Confirm status of mission vehicle
19		Orbital Support Vehicle(s) Transfer to Service Vehicle "A"
	1	Separate support vehicle(s) from Service Vehicle "B"
	2	Transfer to Service Vehicle "A"
	3	Dock support vehicle(s) to Service Vehicle "A"
	4	Transfer logistics requirements to Service Vehicle "A"
20		Service Vehicle "A" Repair and Refurbishment
	1	Perform repair functions on Service Vehicle "A"
	2	Refurbish expendable systems of Service Vehicle "A"
	3	Re-establish spares level in Service Vehicle "A"
21		Recheck Service Vehicle "A"
	1	Perform checkout of Service Vehicle "A"
	2	Confirm status of mission vehicle
22		Orbital Support Vehicle(s) Transfer to Mission Crew Vehicle
	1	Separate support vehicle(s) from Service Vehicle "A"
	2	Transfer to Mission Crew Vehicle
	3	Dock support vehicle(s) to Mission Crew Vehicle
	4	Transfer logistics requirements to Mission Crew Vehicle

Major Operation No.	Event	Description of Operations & Events
23		Mission Crew Repair and Refurbishment
	1	Perform repair functions on Mission Crew Vehicle
	2	Refurbish expendable systems of Mission Crew Vehicle
24		Recheck Mission Crew Vehicle
	1	Perform checkout of Mission Crew Vehicle
	2	Confirm status of mission vehicle. Establish status of convoy vehicles for integrated test.
25		Conduct Convoy Integration Tests
	1	Activate command control systems for convoy vehicles
	2	Perform checkout of convoy vehicles
	3	Perform simulated countdown and launch
	4	Deactivate non-essential systems
	5	Confirm status of mission vehicles for maintenance and surveillance period
	6	Perform tests of spine extension
	7	Perform separation and assembly operations required to provide Earth re-entry with the re-entry vehicle and the M-4 stage propulsion unit. Return vehicle to normal configuration.
26		Conduct Maintenance and Surveillance of Convoy Vehicles
	1a (w/o OLSF)	Establish routine crew duty cycles for maintenance and surveillance of mission vehicles.
	1b (with OLSF)	Transfer support vehicle from crew vehicle to OLSF. (Contains check-out personnel in excess of mission crew manpower level). Return support vehicle and personnel before next Earth launch.
	2	Monitor status of mission vehicle system. Maintain mission vehicle attitudes, separation and orbital altitude.
	3	Confirm status of mission vehicle acceptable for next payload.

Major Operation No.	Event	Description of Operations & Events
27		Launch Propellant Tanker Module No. 1 to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison launch fairing
	3	Transfer to assembly orbit
28		Rendezvous and Dock Propellant Tanker No. 1 with Mission Crew Vehicle
	1	Remove service cover from propellant servicing area
	2	Perform rendezvous maneuver
	3	Align propellant tanker with Mission Crew Vehicle
	4	Dock propellant tanker to Mission Crew Vehicle
	5	Confirm alignment of propellant servicing lines
	6	Confirm mission crew vehicle ready for propellant loading
29		Conduct Propellant Transfer to Mission Crew Vehicle
	1	Perform propellant transfer operation
	2	Monitor propellant servicing area for leakage
	3	Monitor vent system for proper operation
	4	Complete propellant servicing. Confirm propellant quantity in Crew Vehicle propulsion stages
	5	Establish and/or confirm relative position of Mission Crew Vehicle in convoy
	6	Separate propellant servicing lines
	7	Install covers at propellant servicing areas.
	8	Confirm Mission vehicle ready for separation of propellant tanker.
30		Transfer Orbital Support Vehicle (with Checkout Crew) and Propellant Tanker No. 1 to Service Vehicle "A"
	1	Separate propellant tanker from Mission Crew Vehicle
	2	Position modules away from Mission Crew Vehicle

Major Operation No.	Event	Description of Operations & Events
30 (continued)	3	Perform inspection of Mission Crew Vehicle structure. Confirm status due to propellant tanker separation.
	4	Transfer support vehicles and Propellant Tanker No. 1 from Mission Crew Vehicle to Service Vehicle "A"
	5	Perform rendezvous with Service Vehicle "A"
	6	Align Propellant Tanker No. 1 with Service Vehicle "A"
	7	Remove covers from servicing area
	8	Dock Propellant Tanker No. 1 to Service Vehicle "A"
	9	Confirm alignment of propellant servicing lines
	10	Confirm Service Vehicle "A" ready for propellant loading
31		Conduct Propellant Transfer to M-2 Stage of Service Vehicle "A"
	1	Perform propellant transfer operation
	2	Monitor propellant servicing area for leakage.
	3	Monitor vent system for proper operation
	4	Complete propellant servicing. Confirm propellant quantity in M-2 stage
	5	Establish and/or confirm relative position of mission vehicle in convoy system
	6	Separate propellant servicing lines
	7	Confirm mission vehicle ready for separation of Propellant Tanker No. 1
	8	Confirm mission vehicle ready for Propellant Tanker No. 2
32		Separate and Eject Propellant Tanker No. 1
	1	Separate Propellant Tanker No. 1 from Service Vehicle "A"
	2	Position tanker away from convoy and eject out of respective area to prevent inadvertant collision
33		Launch Propellant Tanker No. 2 to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison launch fairing
	3	Transfer to assembly orbit

Major Operation No.	Event	Description of Operations & Events
34		Rendezvous and Dock Propellant Tanker No. 2 with Service Vehicle "A"
	1	Perform rendezvous maneuver
	2	Align propellant tanker with Service Vehicle "A"
	3	Dock tanker to Service Vehicle "A"
	4	Confirm alignment of propellant servicing lines
	5	Confirm Service Vehicle "A" ready for propellant transfer
35		Conduct Propellant Transfer to M-3 Stage of Service Vehicle "A"
	1	Perform propellant transfer operation
	2	Monitor propellant servicing area for leakage
	3	Monitor vent system for proper operation
	4	Complete propellant servicing. Confirm complete service of Service Vehicle "A" propellant
	5	Establish and/or confirm relative position of mission vehicle in convoy system
	6	Separate propellant servicing lines
	7	Install covers on propellant servicing areas
	8	Confirm mission vehicle ready for separation of propellant tanker
36		Transfer Orbital Support Vehicle (with crew) and Propellant Tanker No. 2 to Service Vehicle "B"
	1	Separate propellant tanker from Service Vehicle "B"
	2	Position modules away from Service Vehicle "A"
	3	Perform inspection of Service Vehicle "B" structure. Confirm status due to propellant tanker separation.
	4	Transfer support vehicle and Propellant Tanker No. 2 from Service Vehicle "A" to Service Vehicle "B"
	5	Perform rendezvous with Service Vehicle "B"
	6	Align propellant tanker with Service Vehicle "B"

Major Operation No.	Event	Description of Operations & Events
36 (continued)	7	Remove covers from servicing area
	8	Dock propellant tanker to Service Vehicle "B"
	9	Confirm alignment of propellant servicing lines
	10	Confirm Service Vehicle "B" ready for propellant loading.
37		Conduct Propellant Transfer to Service Vehicle "B"
	1	Perform propellant transfer operation
	2	Monitor propellant servicing area for leakage.
	3	Monitor vent system for proper operation
	4	Complete propellant servicing. Confirm propellant quantity in Service Vehicle "B"
	5	Establish and/or confirm relative position of mission vehicle in convoy.
	6	Separate propellant servicing lines
	7	Install covers at propellant servicing areas
	8	Confirm mission vehicle ready for separation of Propellant Tanker No. 2
	9	Establish refurbishment requirements for systems of convoy vehicles to bring systems to mission readiness condition.
38		Separate and Eject Propellant Tanker No. 2
	1	Separate Propellant Tanker No. 2 from Service Vehicle "B"
	2	Position tanker away from convoy and eject out of respective area to prevent inadvertant collision.
39a (w/o OLSF)		Launch Orbital Support Vehicle to Earth Orbit
	1	Launch to parking orbit
	2	Separate and jettison fairing
	3	Transfer to assembly orbit

Major Operation No.	Event	Description of Operations & Events
39b (with OLSF)		Transfer Orbital Support Vehicle from Service Vehicle "B" to OLSF for re-supply.
	1	Transfer support vehicle from Service Vehicle "B" to OLSF for resupply
	2	Rendezvous and dock support vehicle with OLSF
	3	Transfer logistics requirements from OLSF to support vehicle
	4	Transfer support vehicle from OLSF to Service Vehicle "B"
40		Rendezvous and Dock Orbital Support Vehicle with Service Vehicle "B"
	1	Perform rendezvous maneuver
	2	Dock support vehicle to Service Vehicle "B"
	3	Transfer logistics requirements to Service Vehicle "B"
41		Service Vehicle "B" Repair and Refurbishment
	1	Perform repair functions
	2	Refurbish expendable systems
	3	Re-establish spares level in Service Vehicle "B"
42		Conduct Checkout of Service Vehicle "B"
	1	Perform complete checkout of Service Vehicle "B" systems
	2	Perform complete checkout of all auxiliary mission vehicles
	3	Confirm status of mission vehicle
43		Orbital Support Vehicle(s) Transfer to Service Vehicle "A"
	1	Separate support vehicle(s) from Service Vehicle "B"
	2	Transfer to Service Vehicle "A"
	3	Dock support vehicle(s) to Service Vehicle "A"
	4	Transfer logistics requirements to Service Vehicle "A"

Major Operation No.	Event	Description of Operations & Events
44		Service Vehicle "A" Repair and Refurbishment
	1	Perform repair functions on Service Vehicle "A"
	2	Refurbish expendable systems on Service Vehicle "A"
	3	Re-establish spares level in Service Vehicle "A"
45		Conduct Checkout of Service Vehicle "A"
	1	Perform complete checkout of Service Vehicle "A" systems
	2	Perform complete checkout of all auxiliary mission vehicles
	3	Confirm status of mission vehicle
46		Orbital Support Vehicle(s) Transfer to Mission Crew Vehicle
	1	Separate support vehicle(s) from Service Vehicle "A"
	2	Transfer to Mission Crew Vehicle
	3	Dock support vehicle(s) to Mission Crew Vehicle
	4	Transfer logistics requirements to Mission Crew Vehicle
47		Mission Crew Vehicle Repair and Refurbishment
	1	Perform repair functions
	2	Refurbish systems on Mission Crew Vehicle
	3	Confirm status of mission vehicle systems
48		Conduct Integrated Checkout of Mission Crew and Service Vehicles
	1	Activate all systems
	2	Perform convoy vehicle checkout
	3	Perform simulated countdown and launch
	4	Confirm status of mission vehicles. Call for mission crew.
49a (w/o OLSF)		Launch Mission Carrier to Earth Orbit
	1	Launch to parking orbit

Major Operation No.	Event	Description of Operations & Events
49a (continued)	2	Separate and jettison launch fairing and escape propulsion system
	3	Transfer to parking orbit
49b (with OLSF)		Transfer Mission Crew to Mission Crew Vehicle
	1	Separate support vehicle from Mission Crew Vehicle
	2	Transfer to OLSF
	3	Transfer part of checkout crew from support vehicle to OLSF
	4	Transfer mission crew from OLSF to support vehicle
	5	Separate support vehicle from OLSF
	6	Transfer to mission crew vehicle
50		Rendezvous and Dock with Mission Crew Vehicle
	1	Perform rendezvous maneuver
	2	Dock vehicle to Mission Crew Vehicle
	3	Transfer mission crew to LSS of Mission Crew Vehicle
	4	Transfer checkout crew to carrier or support vehicle
51		Orbital Support Vehicle (or Mission Crew Carrier) Transfer to Parking Orbit
	1	Separate vehicle from LSS
	2	Transfer to parking orbit: orbit must be compatible for providing television coverage during launch of the convoy vehicles.
52		Mission Crew Conduct Missions Readiness Test
	1	Activate convoy vehicle systems
	2	Perform mission vehicle checkout. Confirm status.
	3	Perform simulated countdown and launch.
	4	Confirm ephemeris data and mission vehicles attitude for launch.
	5	Confirm mission vehicles ready for countdown.
53		Conduct Pre-Launch Operations and Countdown
	1	Initiate pre-launch activities

Major Operation No.	Event	Description of Operations & Events
53 (continued)	2	Verify status of mission vehicles systems
	3	Initiate simulated countdown
	4	Complete pre-launch checkout and countdown
	5	Confirm mission vehicles status
	6	Establish mission vehicles ready for final countdown
	7	Mission crew enter re-entry module on Crew Mission Vehicle
	8	Reposition re-entry module on Crew Mission Vehicle for launch from Earth orbit
54		Initiate Final Countdown
	1	Initiate countdown
	2	Complete all countdown up to automatic sequence portion
	3	Initiate countdown "hold" - synchronize launch time with automatic launch count
	4	Initiate automatic countdown sequence
	5	Confirm relative position of other mission vehicles in convoy
	6	Confirm relative position of other mission vehicles in orbit
55		Convoy Launch
	1	Initiate launch sequence
	2	Orbit launch of convoy of mission vehicles
	3	Orbital support vehicles monitor launch and confirm injection
	4a (w/o OLSF)	Support vehicles and Mission Crew Carriers return to Earth
	4b (with OLSF)	Support vehicle returns to OLSF

LUNAR FERRY VEHICLE

APPENDIX B.1
UNSCHEDULED POST MISSION MAINTENANCE

In the process of compiling the Checkout and Countdown Procedures for the Lunar Ferry (Appendix B.3), it was necessary to make some estimate of the amount of time required for unscheduled maintenance on the mission vehicle's subsystems following each mission. The results of this investigation, have been incorporated in the checkout procedures. Unscheduled maintenance of this kind requires a total of 19.49 manhours per mission.

In conducting this analysis, a definition of the Lunar Ferry's subsystems was made based on typical vehicle systems as defined in in-house reports, ALTS study results publications, and by LTV proposals on both Apollo and LEM. A breakdown of subsystems was made by major components utilizing the following steps:

- All major components were analyzed in depth to determine what maintenance could be performed at the replacement level.

- The repair time for each replaceable unit was estimated.

- The probability of failure for each replaceable unit per mission was determined.

- The unit repair time multiplied by the probability of failure resulted in the expected repair time/unit for each mission.

- The sum of all expected repair times for each replaceable unit, within each subsystem, yielded the expected subsystem repair time.

- To compensate for a space environment and zero "G", a "plus" factor of 35% was added to each of the subsystem repair times. The times shown, in the computations which follow, include this plus factor. (Further explanation of this factor is given on Page 7-3, Part I, of this volume).

The final results of the analysis are presented as follows:

Vehicle Subsystem	Repair Time Required Following Each Round Trip (Manhours)
1. Abort Propulsion	4.70
2. Attitude Control	3.68
3. Communications	.75
4. Docking	1.03
5. Electrical Power	.63
6. Environmental Control	.78
7. Instrumentation	.16
8. Navigation and Guidance	1.53
9. Nuclear Propulsion	2.18
10. Propellant Tankage	4.05
Total	19.49 manhours

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	EXPECTED FAILURES						Lunar Ferry	OLSF	E.M.P.	Loss/Pers. Caliler	OSAV	REMARKS
							Orb. Launch to Post Flight Checkout		Orbital Wait		Expected Maint. Time (Min.)							
							A Each x10⁻⁶ / A Total x10⁻⁶		B Each x10⁻⁶ / B Total x10⁻⁶		C A+B	D CxT						
ABORT PROPULSION													x	x	x x	x	x	In the case of repairing leaks, 50% of the estimated repair time was arbitrary selected as the minimum repair time required following each mission.
	H₂ Tank Pressure		Repair leaks (limited to tightening connections)	100		x	65	1000	310	4800	1006	50						
	Temperature Quantity	15	Replace gage, sensors	60		x	65	1000	310	4800	.006	1						Meteoroid impact result would require more extensive repair (applies to all tanks).
	Pressure Regulator Flow Rate	3	Replace regulator	30		x	50	150	240	720	.001							
	O₂ Tank Pressure		Repair leaks (limited to tightening connections).	100		x						50						
	Temperature Pressure Regulator		Replace regulator	30														Assumes regulator located internal to personnel module.
	Quantity Flow Rate		Replace gage, sensors	60		x												
	He Tank Pressure		Repair leaks (limited to tightening connections)	100		x						50						
	Temperature Pressure Regulator		Replace regulator	30		x												Assumes internal regulator
	Quantity Flow Rate		Replace gage, sensors	60		x												Assumes internal regulator
	LH₂ and LO₂ Bleed Valve Operation Time to Open Time to Close	40	Replace valve	100			50	2000	240	9600	.017	1						
	Ignition Control Valve Operation Time to Open Time to Close		Replace valve	100														
	Main Stage Control Valve Operation Time to Open Time to Close		Replace valve	100														

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EXPECTED FAILURES table (rotated):

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout — A Each	A Total	Orbital Wait — B Each	B Total	Expected Maint. Time — A+B (C)	CxL (D)	Lunar Ferry	OLSF	E.M.P.	Logs/Pers. Carrier	OSAV	REMARKS
ABORT PROPULSION (continued)	Thrust Chamber Spark Exciters / Operation / Resistance	4	Replace exciters	160		x	150	600	720	2900	.004	1						
	Gas Generator Spark Exciter / Operation / Resistance		Replace exciters	160		x												
	Helium Control Valve / Operation / Time to Open / Time to Close	1	Replace valve	100														
	Hydraulic Pump / Operation / Pressure Output / Temperature	1	Replace pump	100			110	110	520	520	.007	30						
	Hydraulic Reservoir / Quantity / Pressure Output / Temperature	1	Service reservoir	30			100	100	480	480	.0006	1						Pressurization equipment may be required.
	Engine Gimbal System / Actuator Operation / Input Signals / Feedback Signals / Amplifier Gain / System Response	4	Replace actuator	130		x x	120	480	570	2300	.003	1						
		15	Replace amplifiers	30		x	50	750	240	3600	.005	1						
	Explosive Bolts / EDW Resistance / Switching Operation	8	Remove, replace bolts	120								(24)	x		(x)		x	Explosive bolts on Lunar Ferry and Mars vehicles only.
								TOTAL MAINTENANCE TIME =				209						
ATTITUDE CONTROL	Helium Supply / Quantity / Pressure / Temperature	9*	Replace gage,* sensors / Repair leaks (tighten connections) / Replace sensors	60 / 100 / 60		x x	3000 x10⁻⁶	2700 x10⁻⁶	600 x10⁻⁶	5400 x10⁻⁶	.008	1 / 50	x	x	x	x	x	
	Control Module / Operation / Valve Opening / Valve Closing	42	Replace valve	100		x	250 x10⁻⁶	10,500 x10⁻⁶	250 x10⁻⁶	10,500 x10⁻⁶	.021	2						

ATTITUDE CONTROL (continued)

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout Each	A Total	Orbital Wait Each	B Total	C A+B	D CxT	Lunar Ferry	OLSF	E.M.P.	Log's/Pers. Carrier	OSAV	REMARKS
ATTITUDE CONTROL (continued)	Vent Valve Operation		Replace valve	100														
	Liquid Oxygen Supply Quantity	** 36	Replace gage, sensors**	60		x	250	9000	250	9000	.018	1						
	Pressure		Repair leaks (limited to tightening of connections)	100		x						50						
	Temperature		Replace sensors	60														
	Ratio Control Valve Operation Time to Open Time to Close		Replace valve	100														
	Vent Valve Operation		Replace valve	100		x												
	Fuel Supply Quantity		Replace gage, sensors	60		x						50						
	Pressure		Repair leaks (limited to tightening of connections)	100														
	Temperature Control Valve Operation Time to Open Time to Close		Replace gage, sensors Replace valve	60 100		x												
	Pitch Actuator Control Valves Impedance Position Time Energized Operation		Replace valves	200		x x												
	Yaw and Roll Actuator Control Valves (2) Impedance Position Time energized Operation		Replace valves	200		x												
	Roll Attitude Sensors Reference voltage Null voltage Sensitivity Phasing Wave Form (loaded)	2 9	Replace sensors Replace amplifier	60 20		x	1000 250	2000 2250	1000 500	2000 2250	.004 .007	1 1						

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SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	EXPECTED FAILURES						Lunar Ferry	OLSF	F.M.F.	Lo's/Pers. Carrier	OSAV	REMARKS
							Orb. Launch to Post Flight Checkout A		Orbital Wait B		Expected Maint. Time (Min.)							
							Each	Total	Each	Total	C A+B	D CXT						
ATTITUDE CONTROL (continued)	Pitch Attitude Sensors / Reference voltage / Null voltage / Sensitivity / Phasing / Wave Form (loaded)	2	Replace sensors / Replace amplifier; adjust	60 / 20		x	1000	2000	1000	2000	.004	1						
	Yaw Attitude Sensors / Reference voltage / Null voltage / Sensitivity / Phasing / Wave Form (loaded)	2	Replace sensors / Replace amplifier; adjust	60 / 20		x	1000	2000	1000	2000	.004	1						
	Accelerometers / Null voltage / Response / Linearity / Sensitivity / Reference voltage	3	Replace accelerometers	10		x	400	1200	400	1200	.004	1						
	Guidance Input Channels / Null voltage / Gain / Sensitivity / Impedance / Integration Rate		Replace amplifiers / Adjust amplifier	20 / 10		x												
	Roll Rate Sensors / Reference voltage / Null voltage / Sensitivity / Phasing	3	Replace sensors / Replace amplifiers / Adjust amplifier	60 / 20 / 10		x	400	1200	400	1200	.004	1						
	Pitch Rate Sensors / Reference voltage / Null voltage / Sensitivity / Phasing	3	Replace sensors / Replace amplifiers / Adjust amplifier	60 / 20 / 10		x	400	1200	400	1200	.004	1						
	Yaw Rate Sensors / Reference voltage / Null voltage / Sensitivity / Phasing	3	Replace sensors / Replace amplifier / Adjust amplifier	60 / 20 / 10		x	400	1200	400	1200	.004	1						

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout A Each	Total	Orbital Wait B Each	Total	A+B C	D CxT	Lunar Ferry	OLSF	E.M.P.	Log's/Pers. Carrier	OSAV	REMARKS
ATTITUDE CONTROL (continued)	**Mixer** Null voltage Sensitivity Phasing Amplitude		Adjust amplifier	10		x												
	Thrust Chambers	16	Replace Chamber	150		x	250	2000	250	2000	.004	2						
	Amplifiers Sensitivity Gain Supply voltage Response		Replace amplifiers	60		x												
	Attitude Reference Position Control torquing Power supply voltage Reference signal Sensitivity		Replace amplifiers Adjust amplifier	60 10														
	Computer Self-Check											164						
						TOTAL MAINTENANCE TIME =	X10⁻⁶	X10⁻⁶	X10⁻⁶	X10⁻⁶								
COMMUNICATIONS	**Switching Unit** State Continuity Impedance Isolation	1	Replace unit	25	x	x	1000	1000	960	960	.001		x	x	x	x		
	VHF Transmitter Sensitivity Signal to noise ratio Bandwidth Primary voltage Gain Waveform Output Power	3	Tune or Adjust Replace Transmitter	60 30		x	4000 4000	12,000 12,000	3800 3800	11,400 11,400	.025 .025	1 1	x	x	x	x		

Column header note: Expected Failures — A: Orb. Launch to Post Flight Checkout (Each, Total); B: Orbital Wait (Each, Total); C: A+B; D: CxT (Expected Maint. Time, Min.)

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout — A Each	A Total	Orbital Wait — B Each	B Total	Expected Maint. Time (Min.) A·B / A·C	CXT	Lunar Ferry	OLSF	F.M.P.	Log's/Pers.	Carrier	OSAV	REMARKS
COMMUNICATIONS (continued)	**VHF Receiver** Sensitivity; Signal to noise ratio; Bandwidth; Antenna coupling; Antenna gain	3	Tune or Adjust / Replace Receiver	60 / 30	x		9600 / 9600	29000 / 29000	4600 / 4600	13800 / 13800	.043 / .043	1 / 1	x	x	x	x		x	
	DSIF Transmitter Sensitivity; Signal to noise ratio; Bandwidth; Primary voltage; Gain; Waveform; Output Power	2	Tune or Adjust / Replace Transmitter	60 / 30	x	x	9600 / 9600	19200 / 19200	4600 / 4600	9200 / 9200	.029 / .029	2 / 1	x	x	x				
	DSIF Receiver Sensitivity; Signal to noise ratio; Bandwidth; Antenna coupling; Antenna gain	2	Tune or Adjust / Replace receiver	60 / 30	x	x	33500 / 33500	67000 / 67000	32000 / 32000	64000 / 64000	.133 / .131	8 / 4	x	x	x				
	Lunar Communications Transmitter Sensitivity; Signal to Noise Ratio; Bandwidth; Primary voltage; Gain; Waveform; Output power	2	Tune or Adjust / Replace transmitter	60 / 30	x	x	2000 / 2000	4000 / 4000	3800 / 3800	7600 / 7600	.012 / .012	3 / 1	x	x					
	Lunar Communications Receiver Sensitivity; Bandwidth; Signal to noise ratio; Antenna coupling; Antenna gain	2	Tune or Adjust / Replace Receiver	60 / 30	x		4800 / 4800	9600 / 9600	4600 / 4600	12800 / 12800	.023 / .023	1 / 1	x	x					
	Local Communications Transmitter Sensitivity; Signal to noise ratio; Bandwidth; Primary voltage; Gain; Waveform; Output Power	2	Tune or Adjust / Replace transmitter	50 / 30	x		1200 / 1200	2400 / 2400	4600 / 4600	12800 / 12800	.015 / .015	1 / 1	x	x	x	x	x		

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout — A Total	Each	Orbital Wait — B Total	Each	A+B C	D CxT	Lunar Ferry	OLSF	E.M.P.	Log's/Pers. Carrier	OSAV	REMARKS
COMMUNICATIONS (Continued)	Local Communications Receiver Sensitivity Signal to noise ratio Bandwidth Antenna Coupling Antenna gain	2	Tune or Adjust Replace Receiver	60 30	x		6000 6000	3000 3000	11200 11200	5600 5600	.012 .012	1	x	x	x	x	x	
	Antenna(s) Gain Threshold Radiation pattern VSWR Servo Loop Sensitivity Response Transducer Impedance Linearity Steady-state signal level Transient response	6	Replace Antenna Clean & Tighten Connections Replace Amplifier Replace Actuator Replace Actuator	130 40 20 60 60			4200	700	1920	320	.006	1	x	x	x	x	
	Intercom Switching Continuity Resistance Position Amplifier Buss voltage Sensitivity Gain Frequency response	2	Replace unit Replace Amplifier	20 20			10000	5000	9600	4800	.020		x	x	x	x	
	Television Camera Circuit Vertical Sweep Frequency Video Amplifier Gain Mixer Output Waveform Power Amplifier Sensitivity Gain Input power Voltage current Frequency Response	4	Tune or Adjust Replace camera (11) Tune or Adjust Replace amplifier	50 20 40 20	x	x	24000	6000	26400	6600	.051	1					

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SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/ Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout A Total		Orbital Wait B		Expected Maint. Time (Min.) C A+B	D CxT	Lunar Ferry	OLSF	E.M.P.	Loss/Pers. Critical	OSAV	REMARKS
							Each	Total	Each	Total								
COMMUNICATIONS (Continued)	Receiver	1	Tune or Adjust	60	x													
	Sensitivity		Replace modules or cards for malfunction indicated	20														
	Signal to noise ratio																	
	Bandwidth																	
	IF Gain																	
	Video Output Waveform																	
	Vertical Sweep Frequency																	
	Vertical Amplifier Gain																	
	Horizontal Sweep Freq.																	
	Horizontal Amplifier Gain																	
	Power Supply Voltage																	
	Current																	
	Antenna																	
	Antenna	1	Clean, tighten connections	40							.006	1						
	Actuators	5	Remove, replace	130							.005	1						
	Amplifiers	9	Adjust	60							.007	1						
												33						
DOCKING SYSTEM	Doppler Radar	1	Replace radar	210		x	1500 X10⁻⁶	1500 X10⁻⁶	3000 X10⁻⁶	3000 X10⁻⁶	.005	1	x	x	x			
	Reference Voltage																	
	Output power level																	
	Frequency																	
	Pulse rate																	
	Waveform																	
	Magnetron																	
	Plate Voltage																	
	Grid Current																	
	Antenna Gain		Replace antenna	80			700	700	7000	7000	.008	1						
	Sensitivity	1																
	S/N ratio																	
	Output signal																	
	Waveform																	
	Amplifier																	
	Digital conversion																	
	Comparative check																	
	Servo Loop																	
	Frequency Response																	
	Sensitivity																	
	Null position																	
	Position accuracy																	

TOTAL MAINTENANCE TIME

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout — A Each	A Total	Orbital Wait — B Each	B Total	Expected Maint. Time (Min.) C A+B	D CxT	Lunar Ferry	OLSF	E.M.P.	Logs/Pers. Carrier	OSAV	REMARKS
DOCKING SYSTEM (Continued)	Optical Units Distortion Illumination Control response Transmission Sensitivity Continuity	1	Replace optical units	60		x												Note: 80% of total repair time estimated was assumed for minimum repair time required following each mission.
	Television Monitor Camera Circuit Vertical Sweep Frequency Horizontal Sweep Frequency Video Amplifier Gain Mixer Output Waveform	1	Replace TV unit Tune or adjust camera Replace camera	50 20	x		6000	6000	6600	6600	.013							
	Power Amplifier Sensitivity Gain Input power Voltage current Frequency Response	9	Tune or adjust Replace amplifier	50	x						80%	40						
	Mechanical Terminal Operation Continuity Resistance	1	Replace switches	40														
	Solenoid Devices Operation Position Continuity Resistance Control response		Replace solenoids	40														
	Airlock Pressure Temperature Leakage Pressurizing rate Mixture ratio	1	Replace pressure regulator Replace gage Tighten connections only Replace regulator Replace pump Replace mixture valve	30 30 30 20 40	x	x	4000	4000	15000	15000	.020	4						
			TOTAL MAINTENANCE TIME									46						

ELECTRICAL POWER

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout Each $\times10^{-6}$ (A)	Orb. Launch to Post Flight Checkout Total $\times10^{-6}$ (A)	Orbital Wait Each $\times10^{-6}$ (B)	Orbital Wait Total $\times10^{-6}$ (B)	Expected Maint. Time C A+B	Expected Maint. Time D CXT	Lunar Ferry	OLSF	E.M.P.	Cargo/Pers. Carrier	OSAV	REMARKS
ELECTRICAL POWER													x			x	x	olar array on OL3F Nuclear on two of Mars mission vehicles, fuel cells on lunar Ferry.
	H₂ Fuel Quantity	12*	Replace gage*, amplifier, sensors Calibrate gage or adjust amplifier gain. Sensor replacement time.	30 / 60		x	650	7800	620	7400	.015	1						
	O₂ Fuel Quantity	60*	Replace gage, amplifier, sensors** Calibrate gage or adjust amplifier gain. Sensor Replacement Time	30 / 60		x	500	30000	240	14000	.044	3						
	H₂ Quantity		Replace gage, amplifier, sensors Calibrate gage or adjust amplifier gain. Sensor Replacement Time	30 / 30		x												
	H₂ Pressure Output	24	Repair leaks (time column accounts only for tightening connections)	20		x	500	12000	240	5800	50%	10						/replacement of ruptured cell or lines could require up to 8 hours.
	Pressure Regulator		Replace	30		x					.018	1						
	O₂ Pressure Output		"	20		x												
	H₂ Pressure Output		"	20		x												
	Radiator	3	Replace radiator	130			2500	7500	1200	3600	.011	1						
	O₂ Purge Valve Impedance Time to open Time to close	32	Replace valve	20			500	16000	240	7700	.024	1						
	Cell Heaters Continuity Current		Replace heaters	40														
	Primary Fuel Vent Valve Impedance Time to open Time to close		Replace valve	20														
	Fuel Vent Standby & Shutoff Valve Impedance Time to open Time to close		Replace Valve	20														

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout Each $\times 10^{-6}$	A Total $\times 10^{-6}$	Orbital Wait Each $\times 10^{-6}$ B	Total $\times 10^{-6}$	Expected Maint. Time (Min.) C A×B	D C×T	Lunar Ferry	OLSF	E.M.P.	Long/Pers. Carrier	OSAV	REMARKS
ELECTRICAL POWER (Continued)	Buss Voltage		Adjust	10														Checks of other sys. should reveal source of trouble.
	Total Current		(See "Remarks")															
	Loading response	3*	Replace fuel cell*	360			5000	15000	4200	14400	.030	10						
	Filters	10	Replace filter	15			250	2500	120	1200	.057	1						
								TOTAL MAINTENANCE TIME				28	x	x	x			
							$\times 10^{-6}$	$\times 10^{-6}$	$\times 10^{-6}$	$\times 10^{-6}$								
ENVIRONMENTAL CONTROL	Nitrogen Supply Temperature Quantity Pressure	5*	Replace gage*, amplifier, sensor Repair leaks (tighten connections)	30 20		x	650	3250	600	3100	.007							
	Oxygen Supply Temperature Quantity Pressure	5** ***	Replace gage, amplifier**, sensor*** Repair leaks (tighten connections)	30 20		x	500	2500	500	2400	.005							
	Oxygen Regeneration Blower motor Current	57 11	Replace motor	40			500 35	18500 385	240 75	8900 370	.028 .001							
	Temperature Electrolysis Cell Temperature Current Pressure	1	Replace cell	60			500	500	240	240	.003							
	Reactor Unit Temperature In Temperature Out Coolant Temperature Main heater operation Aux. heater operation Inlet pressure	1	Replace reactor unit	120			2000	2000	960	960	.003	1						
	Reactor gas control valve Operation Time to open Time to close	66	Replace valve	20			500	33000	240	16000	.049	1						
	Accumulator Pressure Temperature	2	Replace accumulator	60	x		1000	2000	480	960	.003							

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout Each	A Total	Orbital Wait Each	B Total	C A+B	D CXT	Lunar Ferry	OLSF	E.M.P.	Lars/Pers. Carrier	OSAV	REMARKS
ENVIRONMENTAL CONTROL (continued)	Nitrogen Pressure Regulator, Operation	10	Adjust regulator / Replace Regulator	10 / 30			500	5000	240	2400	.008							
	Oxygen Pressure Regulator, Operation		Adjust regulator / Replace regulator	10 / 30														
	Oxygen Control Valve, Operation, Time to Open, Time to Close		Replace Valve	20														
	Total Pressure Regulator, Pressure in, Pressure out		Adjust regulator / Replace Regulator	10 / 30														
	Heat Exchanger, Temperature in, Temperature out	3	Replace heat exchanger	60		x x	2500	7500	1200	3600	.011	1						
	Blower, Operation, Motor Current, Motor Temperature	11	Replace blower	60			35	385	35	370	.001							
	Ventilation Subsystem Fan No. 1, Operation, Motor Current, Motor Temperature		Replace fan	45														
	Fan No. 2, Operation, Motor Current, Motor Temperature		Replace fan	45														
	Fan No. 3, Operation, Motor Current, Motor Temperature		Replace fan	45														
	Cabin Pressure Relief Valve, Operation, Pressure to open, Closing pressure		Replace valve	30														
	Cabin Pressure Indication, Sensors, Indicator		Replace sensor / Calibrate / Replace indicator	20 / 30 / 40	x x													

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SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout (A) Each	Orb. Launch to Post Flight Checkout (A) Total	Orbital Wait (B) Each	Orbital Wait (B) Total	Expected Maint. Time (Min.) (C) A+B	Expected Maint. Time (Min.) (D) C×L	Lunar Ferry	OLSF	E.M.P.	Logs/Pers. Carrier	OSAV	REMARKS
ENVIRONMENTAL CONTROL (continued)	Gas Conditioning Subsystem																	
	Fan No. 1																	
	Operation																	
	Motor Current																	
	Motor Temperature		Replace fan	60														
	Fan No. 2																	
	Operation																	
	Motor Current																	
	Motor Temperature		Replace fan	60														
	Fan No. 3																	
	Operation																	
	Motor Current																	
	Motor Temperature		Replace fan	60														
	Fan No. 4																	
	Operation																	
	Motor Current																	
	Motor Temperature		Replace fan	60														
	Differential Pressure Switch																	
	Operation		Replace switch	40														
	Heat Exchanger																	
	Temperature in																	
	Temperature out		Replace heat exchanger	80														
	Water Separator																	
	Humidity Content in		Replace absorbent	15														
	Water flow out		Replace separator	40														
	Fan																	
	Operation																	
	Motor Current																	
	Motor Temperature		Replace fan	45														
	Silica Gel Drum Actuator	2	Replace actuator	60		x	300	600	140	280	.001							
	Operation																	
	Time Controller																	
	Molecular Sieve Drum Actuator		Replace actuator	60														
	Operation																	
	Time Controller																	
	Temperature in																	
	Temperature out																	
	Vacuum Compressor																	
	Operation																	
	Catalytic Burner																	
	Preheater Operation																	
	Burner Operation		Replace burner	40														
	Cooler Operation																	
	Emergency CO_2 Removal Cannister		Replace cannister	30														
	Air Flow in																	
	Air Flow out																	
	Content of CO_2																	

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/ Minutes	Tools Required	Monitored in C/D	EXPECTED FAILURES						REMARKS
							Orb. Launch to Post Flight Checkout		Orbital Wait		Expected Maint. Time (Min.)		
							Each	A Total	Each	B Total	C A-B	D CxT	
ENVIRONMENTAL CONTROL (continued)	Water Recovery and Supply Subsystem												
	Fresh Water Tank Quantity		Replace sensor	40		x							
			Replace indicator	20	x								
	Waste Water Tank Quantity		Replace sensor	40		x							
			Replace indicator	20									
	Nitrogen Pressure Unit	5	Service or replace unit	30									
	Transfer Pump		Replace pump	60			1100	3300	520	1560	.005		
	Operation												
	Motor Current												
	Motor Temperature												
	Recovery Unit		Replace unit	40		x							
	Internal Pressure												
	Condenser Temperature												
	Glycol Cooling Subsystem												
	Coolant Temp. from External Exch.												
	Pumps (2)		Replace pumps	60									
	Operation												
	Motor Temperature												
	Motor Current												
	Flow Rate												
	Accumulator		Service or replace accumulator	30									
	Pressure												
	Temperature												
	Bypass Valves (8)		Replace valve	20									
	Sanitation and Waste Disposal												
	Thermoelectric Units	2	Replace units	40			250	500	120	240	.001		
	Current												
	Temperature												
	Blower Motor		Replace motor	60									
	Operation												
	Current												
	Temperature												
	Repair Leaks			40								20	
	Adjust Regulators			30								12	
												35	
										TOTAL MAINTENANCE TIME =			

Additional column headers (rotated labels): Lunar Ferry, OLSF, E.M.P., Logs/Pers. Carrier, OSAV

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	EXPECTED FAILURES						Lunar Ferry	OLSF	E.M.P.	Logs/Pers. Carrier	OSAV	REMARKS
							Orb. Launch to Post Flight Checkout A		Orbital Wait B		Expected Maint. Time (Min.)							
							Each x10⁻⁶	Total x10⁻⁶	Each x10⁻⁶	Total x10⁻⁶	C A+B	D CxT						
INSTRUMENTATION SYSTEM	Transducer · Pressure · Temperature · Voltage · Current · Position · Angular Displacement · Digital	30	Replace transducers	60			55	1650	40	1200	.003	1	x	x	x	x	x	Excludes signal lights (jewels) and switches
	Signal Conditioning · Format buffers · A-D converters · D-A converters	5 / 2 / 2	Replace buffers · Replace converter · Replace converters	150 / 120 / 60			5500	5500	7400	7400	.013	2						
	Clock		Replace clock	60														
	Data Processing	7	Replace module*	120		x												
	Switching	4	Replace module*	90		x												*Limited to 7 modules easily accessible & automatically checked for quick identification of trouble.
	Computer	5	Replace module*	80		x	5600	5600	7800	7800	.014	2						
	Display and Control	4	Replace module*	120		x	700	700	950	950	.002	2						
										TOTAL MAINTENANCE TIME =		7						
NAVIGATION AND GUIDANCE	Reference Platform · Reference voltage · Signal level · Sensitivity · Torquing · Response	1	Replace platform	480		x	14000 x10⁻⁶	14000 x10⁻⁶	2800 x10⁻⁶	28000 x10⁻⁶	.042	8	x	x	x	x	x	
	Horizon Scanner · Infrared Sensor · Detector · Pre-amp Gain · Amplifier Gain · Output Waveshape · Position Servo System · Actuator · Amplifier	1		150		x	770	770	1540	1540	.002							

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout (A) Each	Orb. Launch to Post Flight Checkout (A) Total	Orbital Wait (B) Each	Orbital Wait (B) Total	Expected Maint. Time (Min.) C A+B	Expected Maint. Time (Min.) D CxT	Lunar Ferry	OLSF	F.M.P.	Logs/Pers. Carrier	OSAV	REMARKS
NAVIGATION AND GUIDANCE (continued)	Azimuth Actuator Scanner Response																	
	Star Tracker Sensitivity Gimbal Actuators Amplifier Gains Resolver Outputs Buffer Amplifiers System Response	1	Replace tracker	180		x	7000	7000	14000	14000	.021	4						
	Clock Synchronization	1	Replace clock	30		x	30	30	60	60	.0001							
	Radar Altimeter Transmitter Power Supply Voltage Frequency Modulated Waveform Pulse Rate Output Power Level Power Level at Antenna Magnetron Plate Current Grid Current Output Waveform Frequency Amplitude	1	Replace altimeter	180			1500	1500	3000	3000	.005	1						
	Receiver Antenna Gain S/N Ratio Sensitivity Amplifier Gain Sensitivity Output Waveform Digital conversion Comparative check	1	Replace antenna	80			700	700	700	700	.008	1						
	Doppler Radar Reference voltage Output power level Frequency Pulse rate Waveform Magnetron Plate voltage Grid current	1	Replace radar	210		x	1500	1500	3000	3000	.005	1						

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	EXPECTED FAILURES						Lunar Ferry	OLSF	E.M.P.	Log/Pers. Carrier	OSAV	REMARKS
							Orb. Launch to Post Flight Checkout (A)		Orbital Wait (B)		Expected Maint. Time (Min.)							
							Each	Total	Each	Total	A+B (C)	CxT (D)						
NAVIGATION AND GUIDANCE (continued)	Antenna Gain / Sensitivity / S/N ratio / Output Signal / Waveform / Amplifier / Digital Conversion / Comparative Check	1	Replace antenna	80			700 X10⁻⁶	700	700	700	.008	1						
	Digital Computer	2	Replace modules	150		x x	52000	104,000	104000	208000	.312	47						
	Space Sextant	1	Replace sextant	90		x x	20000	20,000	40000	40000	.060	5						
							TOTAL MAINTENANCE TIME =					68						
NUCLEAR ENGINE	Propellant Feed System / Tank shut-off valve / Operation / Impedance / Time to open / Time to close / Tank shut-off Pilot Valve / Operation / Impedance / Time to open / Time to close / Reactor Cooldown Valve Assembly / Operation / Impedance / Time to open / Time to close / Turbine Power Control Valve Assy. / Operation / Impedance / Time to open / Time to close / Thrust Chamber Assembly / Remotely Actuated Disconnect / Continuity / Gimbal Operation / Actuators / Amplifier Gain	4	Remove Engine	480	x	x x x x x x x x x	50000 X10⁻⁶	200,000	X10⁻⁶	X10⁻⁶	.2	96	x	—	x			Because of hazardous conditions involved, maintenance will be limited to remove and replace of nuclear engine as total unit. To be accomplished by use of remote manipulators, remote T.V. or other viewing medium. Note: Mars Flyby will not have nuclear propulsion system.

SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout A — Each Total		Orbital Wait B — Each Total		Expected Maint. Time (Min.) C A+B	D CxT	Lunar Ferry	OLSF	E.M.P.	Logs/Pers. Carrier	OSAV	REMARKS
NUCLEAR ENGINE (continued)	Input Signal	1					X10⁻⁶ 5000	5000	X10⁻⁶ 10000	10000	.006	1						
	System Response					x												
	Propellant Feed Control																	
	Sensors					x												
	Amplifier Gain					x												
	Valve Actuator					x												
	Reaction Control Subsystem																	
	Drum Actuator					x												
	Actuator Drive Amplifier					x												
	Neutron Flux Signal Amplifier					x												
	Neutron Flux Control Amplifier					x												
	Temperature Signal Amplifier					x												
	Temperature Control Amplifier					x												
	Neutron Flux Sensor					x												
	Temperature Flux Sensor					x												
	Vector Thrust Subsystem					x												
	Actuators					x												
	Amplifier Gain					x												
	Nozzle Response																		
							TOTAL MAINTENANCE TIME =		X10⁻⁶			97	—	x				
PROPELLANT TANKAGE	Tank Pressure	8	Repair leaks	360	x	x	X10⁻⁶ 100	800	X10⁻⁶ 160	1260	.002	180	x	x				
	Tank Temperature					x												
	Pressure Regulator		Replace Regulator	240	x	x												
	Fuel Quantity					x												
	Flow Rate																	
	Leakage																	

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SYSTEM	SUBSYSTEM/PARAMETER CHECKED AUTOMATICALLY	No. of Units	MAINTENANCE TO BE PERFORMED IN EVENT OF MALFUNCTION	Maint. Time (T) Man/ Minutes	Tools Required	Monitored in C/D	Orb. Launch to Post Flight Checkout (A) Each	Total	Orbital Wait (B) Each	Total	Expected Maint. Time (Min.) C AxB	D CxT	Lunar Ferry	OLSF	E.M.P.	Loss/Pers. Critical	OSAV	REMARKS
PROPELLANT TANKAGE (continued)																		
	Shut-off Valve	30	Replace Valve	240		x	100	3000	160	4800	.008							
	Impedance																	
	Time to open																	
	Time to close																	
	Amplifiers	4					500	2000	160	640	.003							
	Filters	5					50	250	80	400	.001							
	Sensors	20					50	1000	80	1600	.003	180						
								TOTAL MAINTENANCE TIME =										

APPENDIX B.2

FUNCTION AND TASK ANALYSIS OF
MAJOR OPERATIONS AND EVENTS

The purpose of the Function and Task Analysis is to estimate the
man/machine tasks, number of personnel and accumulated time and manhours
required to perform all major operations and events as defined in Appendix
A.3* in support of launching the Lunar Ferry from Earth orbit. The results
of the Checkout and Countdown Procedures (Appendix B.3) were also incorporated
in this analysis.

A brief explanation of the format used in conducting this and
similar analyses (as shown in Appendices C, D, and E) is as follows:

- Column (1) contains a listing of each major operation as
  defined in Appendix A-3, while Column (2) lists each
  event of the operation breakdown.

- Column (3) contains a brief description of what appears
  to be a feasible and logical method of carrying out the
  event (referred to as function).

- Column (4) lists several auxiliary equipment items assumed
  to be available to the orbital checkout crew as needed.

- Column (5) contains an estimate of the number of personnel
  required in Earth orbit to carry out the specific event
  as defined in Column (2).

- Column (6) presents an estimate of the time required to per--
  form each event or function, an accumulative total time,
  and the manhours (or man/minutes) required per function.

- Column (7) contains comments on the effects of having or
  not having an Orbital Launch Support Facility (OLSF) when
  executing the specific function.

For the purpose of estimating the time required in Earth orbit by
the orbital checkout crew to perform the many supporting operations to prepare
and launch the Lunar Ferry, it was assumed that all supplies, fuel, cargo,
passenger personnel, etc., were readily available as needed. The effects of
the availability of Earth launch pads and launch vehicles, realistic Earth
launch rates, etc., on the total time required in orbit to prepare and launch
the vehicle is discussed in Volume II.

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*Post mission operations (Items 22 through 30 as shown in Appendix A.3) were
not included in the Function and Task Analysis as reported herein since they
are basically accounted for in Items 1 through 21.

Figure B.2-1 presents the combined results of the Function and Task Analysis and the Checkout and Countdown Procedures in the form of a simplified time line. The estimated manhours, the accumulated (consecutive) hours and personnel required to perform all routine OLO human tasks to prepare, checkout and launch the Lunar Ferry are listed as follows:

Total manhours   = 290.5
Total accumulated hours   = 69.8
Total orbital checkout personnel   = 9*
Total Lunar Ferry flight crew   = 3
   (Will assist in countdown opera-
   tions only)
Minimum "Logistic" Vehicle Pilots   = 2
   (In this case the "Logistics"
   Vehicle brings the Lunar Ferry
   mission crew and passengers up
   to the assembly orbit. In most
   cases this vehicle is referred
   to as the "Mission Crew and
   Passenger Carrier")

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*Whereas the Checkout and Countdown Procedures (Appendix B.3) show it requires a minimum of 8 OLO checkout personnel to support the Lunar Ferry, the Function and Task Analysis results shows one additional worker will be required to assist and/or substitute for the Launch Control Director whose workload is extremely heavy. Thus a minimum total of 9 orbital checkout crewmen will be required.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed OB/V Without Manipulators	OB/V With Manipulators	Personnel Carrier (AMU)	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment (EOM)	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	Total Accumulated	Man-Minutes Per Function	(7) EFFECTS OF HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
1. Launch nuclear propulsion module & Lunar Ferry com...le to Earth ...it.	a. Launch to parking orbit.	Ground initiated												All controls for this basic operation are executed from the ground
	b. Separate & jettison fairing.	Remote (ground) control by activation of shape charge.												Time required to perform this basic operation is not charged to the time required for the orbital checkout crew to execute their function.
	c. Transfer to assembly orbit.	Ground control.										OLSF would serve as focal point for assembly and checkout operations.		
	d. Separate payload and boost stage.	Ground control.												
	e. Separate launch structure & adapter.	Ground control.												
	f. Activate Lunar Ferry veh. guidance system.	Ground control.												
2. Without OLSF Launch support vehicle (with c/o crew) to earth orbit).	a. Same as 1a above.	Same as noted above												Same as noted in remarks above.
	b. Same as 1b above.													It is assume the support veh. would arrive within a "reasonable" distance (1,000-2,000 yds.) of the Lunar Ferry.
	c. Same as 1d above.													
	d. Same as 1c above.													
3. With OLSF Transfer support vehicle (with c/o crew) to Lunar Ferry.	a. Checkout crew will exit OLSF and enter support vehicle.	Support vehicle will be hard docked to OLSF affording shirt-sleeve environment for crew passage from one system to the other.						1						It is assumed the support veh. will contain the necessary tools and equipment for c/o, repair, servicing, etc., the Lunar Ferry.
	b. Separate support vehicle from OLSF.	A second crewman will most likely be required to perform some type of manual operation to seal hatch while pilot executes reverse thrust to detach veh.						2						
	c. Transfer of support vehicle and c/o crew from OLSF to vicinity of Lunar Ferry.	Execution of standard operating procedures (SOP) for piloting.						1						It is assumed the distance between the OLSF and the lunar ferry would be within 1,000-2,000 yds; thus, the time required for the support vehicle to transverse the distance would be the same as that w/o the OLSF.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — Manipulators OGO w/o V Without	Manipulators OGO w/o V With	Personnel Carrier (AMU)	Hard Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment (IOU)	(5) No. of Men Required in Orbit	(6) Per Function	Total Accumulated	Man-Minutes Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
4. Rendezvous and dock support veh. w/lunar Ferry command module.	a. Perform close-in rendezvous maneuver.	SOP for piloting using direct vision or electronic aids as required.	x					1	All times will start w/this function 10	10	10			This is the final "close-in" phase of the rendezvous maneuver. It is assumed the technique of this maneuver will have been perfected by the 1970-80 time period.
	b. Undock support vehicle w/lunar Ferry command module.	Pilot will manually maneuver support vehicle for join-up w/ command module. Second crewman will prepare hatch.	x					2	10	20	20			It is assumed the technique for this maneuver will also have been perfected by the 1970-80 time period.
	c. Transfer crew and their necessary tools from support vehicle to command module.	Checkout crew, carrying their individual tools, will transverse through the hatch to the pressurized command module.	x					3	15	35	45			Lunar Ferry command module will have been pressurized and checked by a single crewman prior to c/o crew entry. Time for this task is included in that shown above.
	d. Perform checkout of ECS, food preparation, and electrical power systems.	See Remarks			x	x	x	5	755	790	3775	Checkout for both these systems is to be monitored and analyzed aboard the OLSF.	If OLSF not available, c/o monitoring and analyzation must be done from some other location such as earth or the support vehicle.	See checkout and count down procedures, Appendix B.3 C/o and c/d procedures show times required for these events are: 240 min. electrical pwr., 220 min. ECS system, 295 min. food preparation system; total of 755 min.
	e. Deactivate all RF equipment and destruct systems.	Activation of master control switch.						1	05	795	5			This function is required for safety.
	f. Exit Lunar Ferry command module (as required)	Pressure suited crewman will enter alternate hatch, close & secure inner door, depressurize passageway, open outer door & exit vehicle.			x	x		2	20	815	40			Crewman will probably be required to carry limited hand tools and supplies (e.g., fuse) needed for performing extravehicular tasks.
	g. Remove pyrotechnic devices and install fuses.	Using small hand tools, worker will remove pyrotechnic devices and substitute fuses.			x	x		2	20	835	40			There is a possibility that crewman may not have to go outside vehicle to perform this particular task as the same effect may be had by positioning electrical switch from inside vehicle. Since functions g and h can be performed simultaneously, only the time to perform g will be added to the accumulated total.

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FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Min.)		(7) Man-Minutes Per Function	EFFECTS OF		(8) REMARKS
			O&V Without Manipulators	O&V With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	IMU		Per Function	Accumulated Total		HAVING OLSF	NOT HAVING OLSF	
	h. Remove destruct unit from nuclear engine.	Manually remove unit. Crewman will be required to translate to rear of ferry before executing this relatively simple task.				x	x		x	1	20	835*	20			The initial removal of destruct unit (before engine is fired first time) can be performed manually w/ no longer to worker. Subsequent removals will have to be done by remote means.
	i. Store pyrotechnics and destruct unit.	Most likely these units will be manually stored in a "compartment" external to the vehicle.				x	x		x	1	20	855	20			It is necessary to store these devices for future use.
	j. Connect servicing lines from support vehicle to lunar Ferry command module & perform servicing functions.	Such lines may be manually connected from the support veh. to the lunar Ferry, some wholly external while others may be "joined via the hard dock passage way".				x	x	x	x	4	90	945	360	Refurbishing supplies may be stored in facility.		Such servicing lines will most likely include those required to replenish the O_2, N_2, H_2O, hydraulic and cryogenic supply In some cases lines may remain connected for a considerable period of time while servicing and checking operations are being carried out.
	k. Disconnect servicing lines and confirm status.	Primary manual operations.				x	x	x	x	2	40	985	80	Status confirmation will be made to ground and relayed to ground if required.	Status confirmation will be made to ground.	Crewman will confirm functions 4a through 4k have been performed via RF system. Report will be made to OLSF or ground as required.
	l. Replace routine replacement items if required such as: o guidance equip. o components of reaction control system, etc.	It is anticipated such replacement will be done by major component or unit substitution; both extra and intervehicular tasks will be required.				x	x	x	x	2	110	1095	220			G/D's concepts requires the inertial system & the computer be replaced before each flight. Prior to the first Lunar Ferry flight, the task would not have to be performed.
5. Perform c/o of nuclear propulsion & Lunar command module.	a. Checkout nuclear propulsion system (no re-fueling). b. C/o guidance system. c. C/o navigation sys. d. C/o attitude control system.	Function description given in Checkout and Countdown Procedures, Appendix B.3.		x		x			x	5 (avg)	575	1470 1875				See Checkout and Countdown Procedures, Appendix B.3. A man-loading of 5 was used in computing the total man/mins. required for this operation.

*Time in this column will be the same as in the preceding item when functions are performed concurrently.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — Manipulators Without O&V with	Manipulators With O&V with	Personnel Carrier	AMU / Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intravehicular Tools/Equipment	EMU	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	Total Accumulated	Man-Minutes Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
5. Launch Lunar Ferry Payload No. 1, including crew 1, passenger carrier, cargo module, propellant tanker to Earth orbit.	a. Same as 1a b. Same as 1b c. Same as 1c d. Same as 1d										1470				All operations ground controlled; time to perform this entire operation is not charged to the time required for orbital checkout crew to perform their role.
7. With OLSF transfer lunar base crew from crew and passenger carrier (Item 1) to OLSF.	Proceed from payload No. 1's position in Earth orbit to the OLSF and hard dock w/latter.	SOP piloting, rendezvous and hard docking techniques.	x		x				2	30*	1500	60	lunar base crew (10 in number) would be placed aboard OLSF and would remain here while Lunar Ferry is being readied.	Without OLSF lunar base crew would have to be quartered: o Aboard the crew and passenger carrier (which was part of payload No. 1). o Aboard the support vehicle o Aboard the Lunar Ferry or some combination of the three. lunar base crew would proceed from their arrival position in Earth orbit direct to Lunar Ferry.
8. Rendezvous & dock crew and passenger carrier, lunar cargo module & propellant tanker module to Lunar Ferry command module.	a. Perform rendezvous maneuver.	SOP piloting (rendezvous) techniques.			x				1	10	1510	10	If payload No. 1 proceeds from OLSF to Lunar Ferry, an additional 20 mins. would be req'd.		The crew and passenger carrier No. 1 has two pilots who will be available for piloting the carrier at all times. They will remain with the carrier while the carrier is in Earth orbit or will stay in OLSF.
	b. Disengage support vehicle from lunar Ferry command module.	Execution of separation maneuver. Second crewman will be required to secure hatch.							2	10	1510	20			Time to perform function b is not charged to the accumulated total since this function could be performed concurrently w/a.
	c. Dock crew and passenger carrier, lunar cargo module & propellant tanker module to Lunar Ferry command module.	Execution of SOP docking maneuver by the carrier pilot.			x				2	10	1520	20			
	d. Transfer personnel and handcarried cargo (as applicable) from crew and passenger carrier to Lunar Ferry command module.	All performed within shirt-sleeve environment. Routine locomotion movement.							1	30	1550	30			Number of personnel transferred, if any, will depend upon existence of OLSF.

*The time req'd. to translate from payload No. 1's initial position in orbit to the lunar ferry is assumed to be the same as that time req'd. to translate from the same position to the OLSF.

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FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Manipulators Without OSAV	Manipulators With OSAV	Personnel Carrier	AMU	Extravehicular Soft Suit and Tools/Equipment	Intervehicular Soft Suit and Tools/Equipment (BMU)	(5) No. of Men Required in Orbit	(6) Per Function	Total Accumulated	Min-Minutes Per Function	(7) HAVING OLEV	NOT HAVING OLEV	(8) REMARKS
	e. Deactivate all RF equipment and pyrotechnic devices on carrier, lunar cargo module and propellant tanker; remove devices.	Same as Item 4g.				X	X		2	30	1550	60			Function e can be performed while d is being carried out; thus, time for e is not chg'd to the accumulated total
	f. Store pyrotechnic devices and reactivate systems as required.	Same as 4i.				X	X		1	20	1570	20			
	g. Verify propellant tanker and lunar Ferry propulsion module ready for vehicle positioning.	Visual inspection of servicing areas of both modules. External inspection may be required in some instances. Covers may also have to be removed.				X	X		2	30	1600	60			Propellant tanker and lunar cargo module are still effectively "tied" together as one unit.
9. Position propellant tanker module & lunar cargo module on nuclear propulsion module.	a. Execute payload turn-around.	This maneuver may be accomplished by the aid of a OSAV w/some type(s) of manipulators perhaps assisted by an extravehicular worker.		X		X	X		2	10	1610	20			At least one (or more) extra-vehicular workers will be require to assist in the performance of this entire operation (i.e., No. 9.)
	b. Position front of propellant tank adjacent to propulsion module.	Same as noted in (a) above.		X		X	X		2	10	1620	20			
	c. Separate propellant tanker from cargo module.	Probably by execution of pilot controls in crew and passenger carrier while tug maintains hold on tanker.		X		X	X		5	20	1640	60			
	d. Position propellant tanker parallel w/ propulsion module & attach req'd. structure.	Same as in 9a w/ extravehicular worker assisting in attaching req'd. structure.		X		X	X		3	30	1670	90			
	e. Confirm alignment of propellant transfer lines between propellant tanker & propulsion module.	Extravehicular worker will confirm.				X	X		2	10	1680	20			

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — Manipulators Without OB/V	Manipulators With OB/V	Personnel Carrier	AMU	Extravehicular Soft Suit and Tools/Equipment	Intravehicular Soft Suit and Tools/Equipment	(5) No. of Men Required in Orbit	(6) Per Function	(6) Total Accumulated	(7) Man-Minutes Per Function	(7) EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	f. Continue rotation & positioning of lunar cargo module positioning latter in front of propulsion module.	By operation of controls within crew and passenger carrier. Assistance may also be required by "tug".	x						3	20	1700	60			
	g. Retract booms - confirm positioning of cargo module on propulsion module; attach cargo module.	By operation of controls in Lunar Ferry command module. Extravehicular worker and/or C&V operator may confirm.	x	x		x	x		2	15	1715	30			
	h. Separate carrier from cargo module.	By operation of controls within carrier.							2	20	1735	40			
	i. Extend booms and rotate carrier and ferry command module.	By pilot operation of controls within Lunar Ferry command module.							1	10	1745	10			Extravehicular worker(s) must re-enter command module at completion of this operation.
10. Transfer crew and passenger carrier No. 1 to parking orbit.	a. Transfer personnel (as req'd) from Lunar Ferry command module to carrier.	By individual passage through pressurized hatch from Lunar Ferry to carrier.			x				1	20	1765	20			If worker is not already outside the vehicle as a result of prior task requirements, then adequate time must be allotted for vehicle exit to perform b.
	b. Install pyrotechnics (as req'd) on carrier.	By manual operation of extravehicular worker.	x	x	x	x	x		2	30	1795	60			This function can be performed concurrently with b, however it is estimated 30 mins. additional time will be req'd.
	c. Verify carrier status acceptable for orbital stay, then separate the carrier from the command module.	This will consist of securing and visual inspection of hatches and pilot pre-flighting carrier prior to separation. Pilot will then execute SOP separation maneuver.			x	x			2	30	1825	60			
	d. Transfer carrier to parking orbit.	SOP pilot techniques by carrier pilots.			x				2	30	1825	60	Conceivably carrier could be docked to OLSF rather then placed in a "parking orbit". Pilots would be quartered in OLSF.	Pilots would remain in the carrier in "parking orbit" to assist as required.	Time req'd for this function is not counted against the accumulated total.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) EDW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — Manipulators without O&V/V	Manipulators with O&V/V	Personnel Carrier	AMU	Tools/Equipment and Soft Suit and Extravehicular	Tools/Equipment and Soft Suit and Intravehicular	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	Total Accumulated	(7) Man-Minutes Per Function	HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	e. Repair and/or re-furbish Lunar Ferry command module systems as required.	This function may require the support veh. be re-docked w/ the ferry – depending upon what re-servicing must be accomplished (if any).	x						6	80	1905	480			Such systems as O_2, N_2, H_2O, etc., may need to be refurbished. A man-loading of 6 was used in computing total man-minutes for this function.
	f. Confirm status of Lunar Ferry and establish spare parts requirements (if any).	Visual inspection; activation of systems; monitoring systems operation, etc.				x		x	4	40	1945	160			This function and that shown in e are "clean-up" tasks following refurbishing operations of Payload No. 1.
	g. Deactivate all non-essential systems.	Manipulation of switches.							2	05	1950	10			Functions g and h performed concurrently.
	h. Call for next veh. from earth base.	Voice communication w/ earth.							1	05	1950	05	OLSF could perform this function		
11. Launch crew, passenger carrier, lunar cargo module and propellant tanker module No. 2 to Earth orbit.	a. Same as in 1a. b. Same as in 1b. c. Same as in 1c. d. Same as in 1d.														See Remarks in Item No. 6 above.
12. With OLSF: Transfer lunar base crew from crew and passenger carrier (Item 11) to OLSF	Proceed from payload No. 2's position in earth orbit to the OLSF and hard dock w/ latter.	SOP piloting techniques.			x				2	30	1980	60	Due to additional lunar base crew-men would be quartered aboard the OLSF while Lunar Ferry is being readied.	Same as in Item No. 7 above.	Same Remarks as in Item No. 7 above.
13. Rendezvous & dock payload No. 2 w/Lunar Ferry command module.	All functions same as in No. 8 above.	Same as in No. 8	x	x	x	x	x		2 (ave)	100	2080	220			See remarks under Item No. 8. Total man-minutes shown equal actual total extracted from Item No. 8.
14. Position pro-pellant tanker module & lunar cargo module No. 2 on nuclear pro-pulsion module.	Same as functions shown under No. 9 above.	Same as in No. 9 above.				x	x		2.4	145	2225	350			Same as remarks in No. 9 above.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed OBAV Without Manipulators	OBAV With Manipulators	Personnel Carrier	ARM	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intravehicular Tools/Equipment	Task	(5) No. of Men Required in Orbit	(6) Per Function	Total Accumulated	Man-Minutes Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
15. Transfer crew and passenger to carrier No. 2 to parking orbit.	Same as functions shown under No. 10 above w/ deletion of functions g and h.	Same as in No. 10 above.			x	x	x	x	x	3.4 (avg)	145	2225	350			Same as remarks in No. 10 above.
16. Complete c/o of Lunar Ferry.	a. Hard dock support vehicle again w/ Lunar Ferry command module.	SOP hard dock maneuver. Second crewman within support vehicle will prepare and verify condition of hatch between the two systems.														If support veh. has been parked along site of Lunar Ferry during refurbishment operations, it was probably unmanned, thus the two crewmen would have to transfer (probably extravehicularly) to pick up the vehicle.
	b. Perform inspection, repair and c/o of main fueling and abort system.	See c/o and c/d procedures, Appendix		x		x	x	x	x	2	20	2445	680			
	c. Separate support vehicle in preparation for fuel transfer.	SOP pilot separation maneuver. Second crewman will be req'd. to seal the hatch.								4 (avg)	805	3250	3220	Support vehicle could be docked back at OLSF.	W/o an OLSF the support vehicle would remain in parking orbit while propellant was being transferred aboard the Lunar Ferry.	
17. Perform propellant transfer from propellant tankers to nuclear propulsion module	a. Initiate propellant transfer operation.	This function could be performed by an operator in the Lunar Ferry command module simply activating a switch or some other type of manual control.								2	10	3260	20			Internal operator(s) would monitor fuel transfer operations by means of displays & external (visual) observations.
	b. Accelerate the entire mass either linearly or angularly (as req'd).	Whichever maneuver is required to transfer the fuel will most likely be initiated and controlled by pilot action.								1	10	3270	10			Additional personnel will be required to observe & monitor operation (see item c below).
	c. Observe vent lines for proper venting & transfer areas for possible leaks.	By external (direct) vision; may be also by periscope and/or television means.								3	80	3350	240			Function c performed concurrently with b. No additional time or personnel required.
	d. Monitor propellant mass transferred & terminate as req'd.	By monitoring internal displays and operation of fuel transfer controls.										3350				No additional personnel or time required.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Manip. OSV Without	Manip. OSV With	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	EGU	(5) No. of Men Required in Orbit	(6) Per Function	Total Accumulated (Min.)	Man-Minutes Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
18. Separate propellant tanker modules from nuclear propulsion modules.	a. Separate propellant tanker modules from nuclear propulsion module; remove tanks from immediate vicinity of Lunar Ferry.	Tanks separated from ... Ferry propulsion module by manual means.		x		x	x		x	3	70	3420	210			Time is included for transferring the time tanks to a "storage" area.
	b. Inspect propellant servicing areas and replace covers as required; verify no damage from tanker separation.	Extravehicular observation and manual replacement of covers.				x	x		x	2	25	3445	50			
19. Perform Pre-Launch C/O	See Remarks	See Remarks		x		x	x		x	6 (avg)	380	3825	2280			See Pre-Launch Checkout Procedures, Appendix B.2.
20. Separate support vehicle (w/checkout crew) from Lunar Ferry command module.	a. Verify support veh. status & separate vehicle.	SOP pilot separation maneuver								2	10	3835	20			Support vehicle will await return of Lunar Ferry. If no OLSF available, support vehicle would provide television coverage of lunar ferry launch. Support vehicle would also standby for emergency repair to lunar ferry.
	b. Transfer support vehicle to parking orbit.	SOP pilot techniques.					x			2	40	3875	80	If OLSF available, veh. could be docked w/ facility. C/o crew would remain in facility.		
21. Mission crew perform mission readiness test.	a. Confirm status of all veh. systems.	Flight crew will perform SOP "Flight Readiness" checks & simulated countdown.				x				3	60	3925	80			Note: If the 20 passengers (including the 3 flight crew members) to be transferred to the moon have been quartered aboard the OLSF, their transfer to the Lunar Ferry would have been requested prior to this point such that little time would be lost.
	b. Confirm vehicle status, ephemeris data, & vehicle attitude for launch	Communications w/ground or OLSF (as applicable).								2	20	3955	40			
22. Initiate final countdown	a. Start countdown of Lunar Ferry.	Functions described elsewhere								8	05	3960	40	OLSF would initiate, monitor & control.		See Countdown Procedures, Appendix B.3.
	b. Confirm relative positions of carriers No. 1 and 2 and support vehicle.	By voice communications w/ each respective vehicle or w/ OLSF if latter is in control.								1	10	3970	10	OLSF would confirm		Relative positions must be compatible w/television coverage requirements and separation distances for protection from nuclear radiation during flyover and/or flyby.

FUNCTION AND TASK ANALYSIS

RE: REFURBISHMENT, REPAIR, CHECKOUT AND COUNTDOWN OF LUNAR FERRY

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	(6) Total Accumulated	Man-Minutes Per Function	(7) EFFECTS OF HAVING OLSF	(7) NOT HAVING OLSF	(8) REMARKS
	c. Complete all countdown up to automatic sequence portion.	Execution of c/d SOP		8	185	4155	1480			See above, and Appendix ...
	d. Initiate countdown "hold" – synchronize launch time w/ automatic launch count.	Execution of c/d SOP								Automatic function
	e. Initiate automatic c/d sequence.	Push button control.		8	01	4156	08			
23. Lunar Ferry launch.	a. Initiate launch seq. engine start & thrust buildup.	Push button control.								Automatic
	b. Monitor orbit launch seq. – confirm trans-lunar injection.	Monitoring functions.		3	05	4161	15	Monitor OLSF displays and controls.		Ground will monitor if no OLSF available.
	c. Without OLSF – carriers No. 1 and 2, support veh. submit to station keeping requirements & wait for return of Lunar Ferry.			6						...
	d. With OLSF – carriers No. 1 and 2, support veh. return to OLSF and transfer crews to latter to await Lunar Ferry return.			6	30	4191	180	If properly provided for, the three vehs. might remain docked to the OLSF.		
			TOTALS =			4191	17,428			

APPENDIX B.3

CHECKOUT AND COUNTDOWN PROCEDURES

Since more information was available on the Lunar Ferry vehicle, concerning the proposed configuration, the make-up of the subsystems, and the manner of operation, than that of the other three mission vehicles, this vehicle was selected as the basis for establishing orbital launch operations checkout and countdown procedures. Such procedures (for the Lunar Vehicle) should be reasonably typical of the several vehicles under study due to the relative appearance of this vehicle on the time schedule. The procedures are as thorough and as complete as available knowledge permits at the time of their compilation. To compensate for the adverse affects of the space environment and zero "g" conditions, a "plus" factor of 35% is included in all human task required times (see Page 7-3, Part I of this volume). This portion of Appendix B includes:

    o A discussion of the Lunar Ferry checkout crew composition and number.

    o The abbreviations used in the procedures.

    o Part I - Major Subsystems Checkout and a Personnel Utilization - Time Line Chart, Figure B.3-1.

    o Part II - Pre-Launch Checkout and a Personnel Utilization - Time Line Chart, Figure B.3-2.

    o Part III - Countdown and a Personnel Utilization - Time Line Chart, Figure B.3-3.

The results presented herein are as follows:

    (1) A minimum of 8* orbital checkout crew members will be required for checkout and countdown.

    (2) The times required to perform the various major parts are:

    Part I - Major Subsystems Checkout - 45.75 hrs.

      (Note: This does not include the 15 additional hours needed for cargo loading, fuel tanker positioning, etc. - see Appendix B.2)

    Part II - Pre-Launch Checkout - 6.33 hrs.

    Part III - Countdown - 3.08 hrs.

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*The results of the Function and Task Analysis shows that nine will be required. This is due to the heavy work load of the Launch Control Director who will thus need an assistant (see Appendix B.2).

LUNAR FERRY CHECKOUT CREW COMPOSITION AND NUMBER

The following paragraphs discuss the numbers and types of personnel that compose the checkout crew along with the functional definition of their roles in orbital checkout operations. These personnel requirements are predicated on an analysis of checkout and servicing functions pertaining to the Lunar Ferry only. Additional requirements for assembly and checkout of the several Mars Mission vehicles are discussed elsewhere.

(1) In command of all servicing, checkout and launch operations will be a Launch Control Director. His responsibilities will be:

  (a) The scheduling and direction of all activities concerned with servicing, checkout, repair, and launch of the orbital launch vehicle.

  (b) Making critical decisions, based on inputs from members of the checkout crew and from analyses provided by Earth-based launch facilities, pertaining to the readiness of the vehicle for launch.

(2) A Checkout-Programmer-Analyst will be responsible for:

  (a) Ordering the program.

  (b) Programming the automatic checkout equipment to test the various subsystems and/or the integrated systems as directed by the Launch Control Director.

  (c) Monitoring the progression of tests and test results supplied by the automatic checkout equipment.

  (d) Analyzing the data supplied by the automatic checkout equipment for indications of malfunctions or trends that indicate potential malfunctions.

  (e) Preparing a summary report of checkout results for periodic transmission to Earth facilities.

(3) An Electrical Specialist will be responsible for:

  (a) Inspecting, servicing, monitoring the operation of, and making repairs to the electrical power and distribution circuits, lighting system, electrical servo mechanisms and other circuits as required.

  (b) Responsible for servicing and for ensuring the operation of the electrical portions of all destruct systems.

  (c) Assiting the Propulsion and Mechanical Specialist in making repairs to fuel systems, propulsion systems, and associated mechanical linkages.

(4) Life Support Specialist will be responsible for:

    (a) Inspecting, servicing, monitoring the operation of, and making repairs to the environmental control system of the orbital launch vehicle.

    (b) Servicing and checking other elements of the life support such as food storage, water supply, and sanitrary facilities.

(5) An Electronics Specialist will be responsible for:

    (a) Inspecting, servicing, operating, monitoring the operation, and making repairs to such systems and equipment as communications, radar, T.V., electronic checkout, and associated display circuits aboard the orbital launch vehicle.

    (b) Assisting the Guidance and Navigation Specialist in making repairs to the guidance subsystems.

(6) A Guidance and Navigation Systems Specialist will be responsible for:

    (a) Inspecting, servicing, monitoring the operation of, and making repairs to the guidance systems, navigation systems, stabilization and attitude control systems, and systems display circuitry on-board the vehicle to be launched from Earth orbit, referred to as the OLV.

    (b) Assisting the Electronics Specialist in making repairs to communications, radar, and T.V. systems.

(7) A Propulsion and Mechanical Specialist will be responsible for:

    (a) Inspecting, servicing, monitoring the operation of, and making repairs to the reaction control fuel systems, pyrotechnic, ordnance, propulsion fuel systems, propulsion systems, pneumatic and hydraulic systems, and associated mechanical linkages and devices on-board the vehicle to be launched from Earth orbit.

(8) An Orbital Support Assembly Vehicle Operator will be responsible for:

    (a) The transfer of personnel and supplies to and from an Orbital Launch Support Facility and the Orbital Launch Vehicle.

    (b) Assisting the checkout crew aboard the Orbital Launch Vehicle in performing inspection, servicing, and repair functions where assistance is needed exterior to the vehicle.

(c) The operation of the remote maintenance manipulators in the performance of maintenance tasks exterior to the vehicle.

ABBREVIATIONS

Abbreviations which are used in the following procedures are listed below:

LCD	-	Launch Control Director
CPA	-	Checkout-Programmer-Analyst aboard the Orbital Launch Support Facility
CS	-	Electronics Specialist aboard the vehicle to be launched from Earth orbit, referred to as the OLV
ES	-	Electrical Specialist aboard OLV
GS	-	Guidance and Navigation Systems Specialist aboard OLV
LSS	-	Life Support Specialist aboard OLV
PM	-	Propulsion and Mechanical Specialist aboard OLV
OSAVO	-	Orbital Support Assembly Vehicle Operator
GOSS	-	Ground Operated Support System
OLSF	-	Orbital Launch Support Facility
OLV	-	Orbital Launch Vehicle - i.e., the vehicle to be launched from Earth orbit (in this case, the Lunar Ferry).
C/O	-	Checkout
C/D	-	Countdown
LV	-	Personnel Carrier - also termed Crew and Passenger Carrier
PC	-	Pilot Commander, Lunar Flight Crew
PE	-	Pilot Engineer, Lunar Flight Crew
PS	-	Pilot Scientist, Lunar Flight Crew
RCS	-	Reaction Control System
ECS	-	Environmental Control System

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AMU   -   Astronaut Maneuvering Unit

LVP   -   Logistic Vehicle Pilot

PART I - MAJOR SUBSYSTEMS CHECKOUT

Since the procedures discussed herein encompass both servicing and checkout for the initial, as well as for subsequent translunar trips of the Lunar Ferry, checkout begins with a fully assembled vehicle. The flight crew and passengers are not aboard. Checkout procedures have been developed and are presented in three parts as follows:

Part I - The checkout of the major subsystems individually and the re-fueling of the main propulsion system. This part is entitled MAJOR SUBSYSTEMS CHECKOUT.

Part II - The integrated mission vehicle subsystem checkout performed during pre-launch operations and the topping off of all systems. This part is entitled PRE-LAUNCH CHECKOUT.

Part III - The integrated systems check made for confidence during the final countdown. This part is entitled COUNTDOWN.

The checkout schedule is determined by the Launch Control Director (LCD) in coordination with the Ground Operated Support System (COSS), and with consideration given to launch windows for the next mission.

The sequential procedures for conducting Part I - Major Subsystems Checkout of the Lunar Ferry are presented in this section in the form of an actual countdown. Servicing and checkout of all vehicle subsystems and equipment is performed in much the conventional manner by means of visual and manual checks followed by automatic (pre-programmed) equipment checkout. The fundamental make-up and description of the various subsystems and equipment of the Lunar Ferry were based on the results of LTV Astronautic's and Lockheed's Advanced Lunar Transportation System studies as these became available. In some cases, it was necessary to predict the typical state-of-the-art of such equipment for the time period under study.

It is noted in the checkout procedures that the Orbital Support Assembly Vehicle (OSAV) makes many service trips between the vehicle being checked out, i.e., the Lunar Ferry and an Orbital Launch Support Facility (OLSF) to transport expendable supplies, spare parts, personnel, etc. A review of the procedures will further show that little additional over-all checkout time is required because of these trips, since they are being executed concurrently with other tasks. However, in the interest of simplifying the number of operations required for checkout of each spacecraft and to increase the probability of orbital launch operations mission success, it is desirable to limit these trips to a minimum which, in turn, lessens the number of rendezvous and hard dock maneuvers required.

It is assumed that the checkout crewman performing in the space environment would not be more than 65% as effective as he would be in his Earthly surroundings where lighting is generally no problem, where manual dexterity is seldom limited, where objects come to rest in one plane and remain there, etc. Accordingly, all estimated times shown include a plus factor of 35% in the interest of compensating for this degradating condition. (For further explanation, see Page 7-3, Part I, of this volume.).

It is further assumed that the orbital worker has the necessary tools and equipment needed to perform his tasks, and that such items as fuel, cargo, major vehicle segments, spare parts, etc., are available in and around the OLV as required; i.e., the checkout crew does not have to await their arrival from Earth.

The results of the checkout procedures show it requires approximately 45.75 accumulated hours to complete the Major Subsystem Checkout, including refueling of the vehicle.*

The checkout procedures follow:

Sequence No.	Time	Resp.	Task
1	T-2745	LCD	Conducts briefing of all personnel as to radiation hazards and travel to and from the vehicle to be launched from Earth orbit (the OLV).
			- Supervises the individual checking of radiation detection devices for correct operation.
2a	T-2715	LCD	Remotely energizes system necessary to bring the orbital launch vehicle (OLV) attitude and orbit under control.
			- OLV attitude stabilized with respect to the Orbital Launch Support Facility so that nuclear engines point away from the facility.
2b	T-2715	OSAVO	Enters Orbital Support Assembly Vehicle (OSAV) and conducts pre-flight checks.
			- Loads Environmental Control System (ECS) and power source supplies on OSAV.

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*It is noted that approximately 15 hours have been added to this total in the Function and Task Analysis results (Appendix B.2) to account for the additional time required for loading the cargo, positioning of the tankers during refueling, and the performance of those tasks required for handling the pyrotechnic devices.

Sequence No.	Time	Resp.	Task
2b(continued)			- Prepares for transport of checkout personnel.
3	T-2685	LCD	Notifies Ground Operated Support System (GOSS) of his intention to start the checkout.
			- Establishes start time and schedule.
4a	T-2680	OSAVO	Loads checkout personnel aboard the Orbital Support Assembly Vehicle.
4b	T-2680	ES LSS	Enters OSAV for transport to the Lunar Ferry (OLV).
5	T-2665	OSAVO LSS ES	Translates from the Orbital Launch Support Facility to the Lunar Ferry.
6	T-2635	OSAVO	Performs close-in rendezvous to Lunar Ferry.
7	T-2625	OSAVO	Performs hard docking maneuver to Lunar Ferry (OLV).
8	T-2615	LSS ES OSAVO	Enter OLV with auxiliary checkout equipment and tools.
9a	T-2600	ES	Makes visual inspection of secondary power source.
			- Inspects and services the battery system as required. (New batteries will probably have to be installed prior to each mission).
			- Checks voltages.
			- Replaces weak or defective cells (if all new batteries not required prior to each mission).
			Makes visual inspection of the primary power source. Note: It is assumed primary power is by fuel cells.
			- Visually inspects fuel cells.
			- Performs leakage checks on fuel cells.

Sequence No.	Time	Resp.	Task
9a(continued)			- Assisted by OSAVO, resupplies source.
9b	T-2600	LSS	Makes visual inspection of Environmental Control System (ECS).
9c	T-2600	OSAVO	On standby to assist Electrical and Life Support Specialists as required.
10	T-2570	LSS	Performs leakage checks on lines and valves.
11	T-2510	LSS	Confirm and/or verify estimated replacement requirements for resupply of LOX, nitrogen, water, filters, and other ECS expendables. (Note: Resupply amounts established by normal replacement requirements or during post flight check).
12	T-2495	OSAVO	Notifies LCD via OSAV radio of resupply requirements.
13a	T-2490	LCD	Receives notification of ECS resupply requirements.
13b	T-2490	LSS	Cleans and lubricates motors, blowers, and actuators as required.
14	T-2480	OSAVO	Notifies LCD and Checkout-Programmer-Analyst via OSAV radio of readiness for power system checkout (C/O).
15a	T-2475	LCD	Receives notification of intended system checkout.
15b	T-2475	CPA	Receives notification of intended system checkout. - Prepares automatic C/O equipment for check of electrical power systems.
16	T-2465	ES	Starts up primary power source. - Switches OLV load to power source.
17	T-2460	OSAVO	Translates to OLSF for any additional Environmental Control System (ECS) supplies (if required).*

*This trip may not be necessary if all ECS supplies can be established prior to the first trip (see Sequence No. 5).

Sequence No.	Time	Resp.	Task
18a	T-2455	CPA	Starts check of electrical power systems.
			Monitors results on Orbital Launch Support Facility (OLSF) displays.
18b	T-2455	ES	Monitors results on OLV displays.
19	T-2445	ES	Performs unscheduled maintenance.
20	T-2430	OSAVO	Performs close-in rendezvous to OLSF.
21a	T-2425	ES	Performs rechecks as required.
21b	T-2425	CPA	Monitors rechecks on OLSF displays.
22	T-2420	OSAVO	Performs hard docking maneuver.
23	T-2410	OSAVO	Loads ECS supplies.
24	T-2405	ES	On standby.
25	T-2400	CPA	Analyzes results of electrical power system checkout.
26a	T-2380	OSAVO	Translates to Lunar Ferry (OLV) from OLSF.
26b	T-2380	CPA	Prepares summary of checkout results.
			- Stores on tape for transmission to Ground Operated Support System (GOSS) per schedule.
27	T-2360	CPA	On standby.
28	T-2350	OSAVO	Performs close-in rendezvous maneuver and hard dock.
29	T-2315	OSAVO	Unloads ECS supplies.
30a	T-2250	LSS	Assembles new supply tanks to ECS.
30b	T-2250	ES	Assists LSS in tank assembly.
31	T-2210	OSAVO	Notifies LCD and CPA via OSAV or OLV radio of readiness for (ECS) checkout.
32a	T-2205	LCD	Receives notification of ECS checkout readiness.

Sequence No.	Time	Resp.	Task
32b	T-2205	CPA	Receives notification of readiness for ECS checkout. - Prepares automatic checkout equipment for check of ECS.
33	T-2190	ES	Performs visual inspection of vehicle lighting system. - Performs operational check of all lighting. - Replaces bulbs, switches, wiring, as required to ensure proper operation of all lighting. - Performs operational check of all warning lights and annunciators. - Repairs as required.
34a	T-2185	CPA	Starts check of ECS. - Monitors results on OLSF checkout equipment displays.
34b	T-2185	LSS	Monitors results of checks on OLV displays.
35a	T-2185	LSS	Performs unscheduled maintenance.
35b	T-2185	CPA	On standby for rechecks as required.
36a	T-2160	LSS	Performs rechecks as required. Note: If individual emergency ECS systems are available for the 20 passengers these too will require checking during ECS checkout.
36b	T-2160	CPA	Monitors results of rechecks on ECS.
37a	T-2140	CPA	Prepares summary of ECS checkout results. - Records on tape for transmission to GOSS per schedule.
37b	T-2140	LSS	Performs visual inspection of food preparation system.
38	T-2120	LSS	Cleans and tightens connections on resistance heating elements.

Sequence No.	Time	Resp.	Task
39	T-2110	CPA	On standby
40	T-2060	LSS	Performs operational check of food preparation system.
41	T-2050	LSS	Verifies inventory of food supplies aboard. (Note: Prior inventory completed during post mission checkout of Ferry). - Lists additional requirements for support of checkout crew during the servicing and checkout operations.
42a	T-2035	OSAVO	Translates to OLSF for food supplies.*
42b	T-2035	LSS	Performs visual inspection of food storage and refrigeration systems. - Cleans, tightens connections, and performs leakage checks on refrigeration systems.
43	T-2005	OSAVO	Performs close-in rendezvous maneuver with OLSF.
44	T-1995	OSAVO	Performs hard docking with OLSF.
45	T-1985	OSAVO	Loads food supplies aboard Orbital Support Assembly Vehicle.
46	T-1945	LSS	Checks operation of refrigerator temperature control system.
47a	T-1925	OSAVO	Translates to OLV with food supplies.
47b	T-1925	LSS	Performs visual inspection of potable water heating system.
48	T-1915	LSS	Makes an operational check of water temperature control system.
49	T-1905	LSS	Performs operational check of waste disposal system.
50	T-1895	OSAVO	Performs close-in rendezvous maneuver.

*This trip may not be necessary if post-mission checkout has previously determined all food resupply requirements. Accordingly, all such supplies could be carried aboard the OSAV during the first trip.

Sequence No.	Time	Resp.	Task
51a	T-1885	OSAVO	Performs hard docking to Lunar Ferry.
51b	T-1885	LSS	Notifies LCD via OLV radio of status of life support systems and stands by to assist Orbital Support Assembly Vehicle Operator (OSAVO) in bringing food supplies aboard.
52a	T-1875	OSAVO ES LSS	Unload and store food supplies.
52b	T-1875	CPA	Summarizes results of life support systems checks. - Stores on tape for transmission to GOSS per schedule.
53	T-1845	OSAVO	Notifies LCD via OSAV radio of OLV readiness to receive the remainder of the C/O crew.
54a	T-1840	LCD	Receives notification of readiness to receive the remainder of the C/O crew.
54b	T-1840	OSAVO	Starts translation to OLSF.
55	T-1810	OSAVO	Performs close-in rendezvous maneuver.
56a	T-1800	OSAVO	Performs hard docking to OLSF.
56b	T-1800	CS GS PM	Prepare to board OSAV for transfer to OLV.
57a	T-1790	OSAVO	Loads Electronics Specialist (CS), Guidance and Navigation Specialist (GS), and Propulsion/Mechanical Specialist (PM) and auxiliary C/O equipment for transport to OLV.
57b	T-1790	CS GS PM	Enter Orbital Support Assembly Vehicle (OSAV) for transport to OLV.
58	T-1775	OSAVO CS GS PM	Translation to OLV.

Sequence No.	Time	Resp.	Task
59	T-1745	OSAVO	Performs close-in rendezvous maneuver.
60	T-1735	OSAVO	Performs hard docking to OLV.
61	T-1725	OSAVO CS GS PM	Unload OSAV of personnel and equipment.
62a	T-1700	OSAVO	Returns to OLSF to load fuel supplies per PM needs.
62b	T-1700	CS	Makes visual inspection of communications equipment. - Checks for security of mounting and/or obvious damage.
62c	T-1700	GS	Performs visual inspection of guidance, navigation, and attitude control systems.
62d	T-1700	PM	Performs leakage tests on reaction control system. - Notifies LCD of fuel requirements for reaction control system.
63	T-1700	GS	Replaces inertial platform as required.
64	T-1655	OSAVO	Stands by for fuel requirements notification.
65a	T-1645	OSAVO	Loads fuel supply for reaction control system.
65b	T-1645	PM	Performs visual inspection of engine and fuel controls. - Inspects and calibrates fuel and engine controls.
66	T-1625	OSAVO	Returns to OLV.
67	T-1610	GS	Performs self-checks of guidance computer.
68	T-1595	GS	Notifies LCD of system readiness for checkout.
69a	T-1590	GS	Turns on all systems and allows them to stabilize.

Sequence No.	Time	Resp.	Task
69b	T-1590	CPA	Prepares automatic C/O equipment for checks of guidance, navigation, and attitude control systems.
70	T-1585	CS	Cleans, tightens, adjusts, calibrates equipment as required.
71	T-1580	CPA	Starts checkout of guidance, navigation, and attitude control systems. Note: If reaction control system jets are pulsed during checkout, the pulse sequence should be such that it results in no orbit change.
72a	T-1570	CPA	Monitors results on OLSF displays.
72b	T-1570	GS	Monitors results on OLV displays.
73a	T-1550	GS	Performs unscheduled maintenance - Schedules and monitors rechecks as required.
73b	T-1550	CPA	Monitors rechecks as required. - Summarizes C/O results. - Stores on tape for transmission to GOSS per schedule.
74	T-1465	OSAVO	Notifies LCD and CPA via OLV radio of readiness for communications C/O. Note: Although the communications equipment is not formally checked out until this point in time, it is logical to assume it has been in use, periodically, during checkout.
75a	T-1460	LCD	Receives notification of readiness for communications checkout.
75b	T-1460	CPA	Prepares automatic C/O equipment for check of communications systems.
75c	T-1460	GS	Calls for and receives from GOSS navigation and guidance data (orbital characteristics).
76a	T-1445	GS	Confirms navigation and guidance read-outs on OLV displays.

Sequence No.	Time	Resp.	Task
76a(continued)			- Calibrates system as required.
			- Rechecks OLV read-outs with GOSS per schedule.
			- Performs manual control tests and monitors results on OLV displays.
76b	T-1445	GS	- Confirms with LCD the status of the guidance, navigation, and attitude control systems.
77a	T-1440	CPA	Starts C/O of communications system.
			- Monitors results of C/O on OLSF displays.
77b	T-1440	CS	Monitors results of C/O on OLV displays.
78a	T-1410	CS	Performs unscheduled maintenance on communications equipment.
79a	T-1385	GS	Monitors system to determine platform drift and position updating requirements.
			- Keeps LCD informed of results of monitoring.
79b	T-1385	LCD	Monitors results of GS monitoring of platform drift and position updating requirements.
80a	T-1375	CS	Monitors rechecks of communications systems on OLV displays.
80b	T-1375	CPA	Performs required rechecks of communications systems.
			- Monitors results of rechecks on OLSF displays.
81a	T-1355	CPA	Analyzes results of communications C/O.
			- Stores on tape for transmission to GOSS per schedule.
81b	T-1355	CS	Notifies LCD of readiness for confirmation checks with GOSS.
82a	T-1355	LCD	Notifies Electronics Specialist of schedule for confirmation checks.
			- Monitors results.

Sequence No.	Time	Resp.	Task
82b	T-1355	CS	On standby.
83	T-1350	CS	Communicates directly with GOSS per schedule.
84	T-1340	CS	Receives confirmation from GOSS.
85	T-1330	LCD	Dispatches remote controlled vehicle unit for inspection.
86	T-1325	OSAVO	Mans controls of inspection vehicle.* - Flies inspection vehicle to and around OLV, using T.V. receiver for maneuvering intelligence.
87a	T-1300	LCD	Provides inspection checkpoints sequence to the Orbital Support Assembly Vehicle Operator. - Directs repairs of vehicle as required.
87b	T-1300	PM	In coordination with LCD's directions, energizes fuel cell switches, and engine main fuel lines for leakage checks.
87c	T-1300	CPA	Analyzes results of inspection on T.V. monitor.
88	T-1285	OSAVO	Mans controls of repair vehicle to effect repairs as required.
89	T-1185	CPA	Summarizes results of inspection. - Stores on tape for transmission to GOSS per schedule.
90a	T-1145	LCD	Directs inspection vehicle to effect repairs as required and as possible.
90b	T-1145	OSAVO	Effects repairs with remote maintenance vehicle.
91	T-1080	PM	Straps on Astronaut Maneuvering Unit (AMU) and checks the units ECS. - Egresses from OLV.

*See Item Sequence No. 130a for comments concerning requirements.

Sequence No.	Time	Resp.	Task
91 (continued)			- Inspects abort fuel system, lines, and propulsion unit.
92a	T-970	ES	Pressurizes abort fuel system.
92b	T-970	PM	Inspects system for leakage.
93	T-940	PM	Performs unscheduled maintenance on abort propulsion unit.
94	T-730	PM	Re-enters the OLV.*
95	T-720	OSAVO	Translates via OSAV to OLSF for fuel supply.
96	T-710	PM	Notifies Launch Control Director (LCD) of system readiness for abort propulsion system automatic checkout.
97a	T-705	LCD	Receives notification of readiness for abort system automatic checkout.
97b	T-705	CPA	Receives notification of readiness for abort propulsion and fuel system C/O.
			- Prepares automatic C/O equipment.
98	T-690	OSAVO	Performs close-in rendezvous maneuver to OLSF.
99a	T-685	CPA	Monitors results of abort propulsion and fuel system C/O on OLSF displays.
99b	T-685	PM	Monitors results of abort propulsion and fuel system C/O on OLV displays.
100	T-680	OSAVO	Performs hard docking to OLSF.
101	T-670	OSAVO	On standby.
102	T-655	PM	Notifies LCD of requirements for abort fuel resupply.
103a	T-650	LCD	Advises OSAVO of fuel resupply requirements.
103b	T-650	GS	Calibrates optical displays.

*It is assumed the life support unit will not support the extravehicular worker for more than four consecutive hours, thus, the PM will have made at least one re-entry into the OLV prior to this time.

Sequence No.	Time	Resp.	Task
103b(continued)			(Note: It may be necessary to perform this function prior to setting up the inertial platform).
103c	T-650	ES CS	Assist in calibration of optical displays.
103d	T-650	OSAVO	Loads abort system fuel resupply.
103e	T-650	PM	Assists in calibration of optical displays.
104a	T-620	CS	Calibrates electronic displays as required.
104b	T-620	ES GS PM	Assist in calibration of electronics displays.
104c	T-620	OSAVO	Translates to OLV.
105	T-590	OSAVO	Performs close-in rendezvous maneuver to OLV.
106	T-580	OSAVO	Performs hard docking to OLV.
107	T-570	PM OSAVO	Transfers abort propulsion fuel. Assists in transfer of abort propulsion fuel. Note: By this time, it is assumed that (a) payloads No. 1 and 2 - each composed of a mission crew and passenger carrier, a lunar cargo module, and a propellant tanker for fueling the main propulsion system of the Lunar Ferry, have arrived in assembly orbit in the proximity of the Lunar Ferry and that (b) the pilot of each payload has maneuvered his system and:

1. Docked with the Lunar Ferry.
2. Has rotated the "tanker" into position.
3. Has separated the tanker from the cargo module.
4. Has rotated the crew and passenger carrier and cargo module into place.
5. Has separated cargo module from the crew and passenger carrier and secured the former.

Sequence No.	Time	Resp.	Task
108a	T-530	PM	Notifies LCD of abort system status.
108b	T-530	OSAVO ES	Don astronaut maneuver unit and checks it out.
109	T-525	LCD	Receives notification of abort system status.
110	T-510	OSAVO ES	Egress from Lunar Ferry and maneuver to fuel tanks.
111	T-490	OSAVO	Connect and/or verify propellant tanker No. 1 properly secured to Lunar Ferry.
112	T-475	OSAVO ES	Connect propellant tanker No. 1 lines to Lunar Ferry.
113	T-455	OSAVO	Connect propellant fuel tank No. 2 to Lunar Ferry.
114	T-440	OSAVO ES	Connect propellant tanker No. 2 lines to Lunar Ferry.
115	T-420	OSAVO ES	Insure connection of lunar cargo module to Lunar Ferry.
116	T-400	OSAVO ES	Ingress into Lunar Ferry.
117	T-380	PM	Notifies LCD of intent to start refueling operations.
118	T-375	LCD	Receives notification of intent to start refueling operations.
119	T-370	PM	Activates OLV to perform fuel transfer operations.
120	T-350	PM	Starts propellant tanker pumps and monitors fuel transfers.
121a	T-280	PM	Notifies LCD of completion of fuel transfer.
121b	T-280	OSAVO ES	Egress from OLV to disconnect empty propellant tankers.
122	T-275	LCD	Acknowledges completion of fuel transfer message.
123	T-260	OSAVO ES	Disconnect both propellant tankers.

Sequence No.	Time	Resp.	Task
124	T-220	OSAVO ES	Move propellant tankers to "storage" area.
125	T-190	OSAVO ES	Return to Lunar Ferry.
126a	T-165	OSAVO	Ingresses into OSAV.
126b	T-165	PM	Notifies LCD of readiness of fuel system and engine for automatic C/O.
127a	T-160	OSAVO	Translates to OLSF for life support supplies (pre-calculated).
127b	T-160	LCD	Receives notification of readiness for C/O.
127c	T-160	CPA	Prepares automatic C/O equipment for check of fuel system and nuclear engine.
127d	T-160	PM	On standby to assist in C/O.
128a	T-140	PM	Monitors results of C/O on OLV displays.
128b	T-140	CPA	Monitors results of C/O on OLSF displays.
129	T-130	OSAVO	Performs close-in rendezvous maneuver to OLSF.
130a	T-120 T-120	OSAVO LCD	Performs hard docking to OLSF. Directs inspection vehicle to effect repairs.* (Note: Inspection vehicle may be a remotely operated system carried aboard the OLV).
130b	T-115	PM	Effects repairs with remote maintenance vehicle.
131	T-110	OSAVO	Assists OLSF crew in loading life support supplies aboard OSAV.
132	T-90	OSAVO	Translates to OLV.
133	T-60	OSAVO	Performs close-in maneuver.

*Where adequate protection cannot be afforded the extravehicular worker, a need exists for some type of remote inspection and repair vehicle to perform in and around the "hot" engine. Design requirements, methods of control, the location of the remote operator, etc., are only some of the numerous problems requiring investigation.

LCD	Launch Control Director (OLSF)
OSAVO	Orbital Support Assy. Veh. Opr.
ES	Electrical Specialist
LSS	Life Support Specialist
CS	Electronics Specialist
GS	Guidance & Nav. Specialist
PM	Propulsion-Mechanical Special.
CPA	Checkout-Programmer/Analyst (OLSF)

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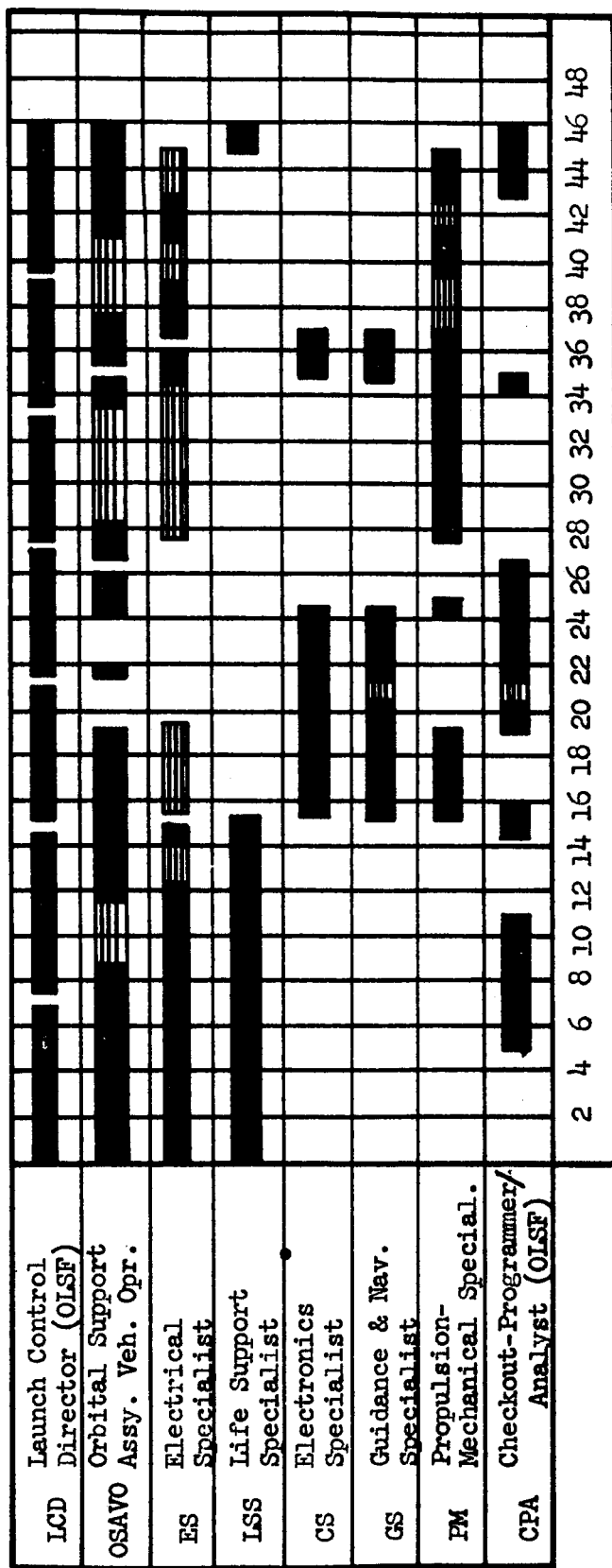
H O U R S

Basic Task

Standby

As shown in the illustration, the approximate manhours required for servicing and major subsystems checkout of the Lunar Ferry equals:

Basic Task - 166
Standby - 35

Total = 201

FIGURE B.3-1:
MAJOR SUBSYSTEM SERVICING AND CHECKOUT PERSONNEL UTILIZATION - TIME LINE

Sequence No.	Time	Resp.	Task
134	T-50	OSAVO	Performs hard docking to OLV.
135	T-40	OSAVO	Assists in unloading life support supplies into OLV.
136	T-25	CPA	Summarizes results of C/O of fuel system and nuclear engine C/O.
137a	T-20	OSAVO	Returns to OLSF and stands by to assist in Pre-Launch Checkout. (Note: Since translation time, close-in maneuver, and hard docking takes 50 minutes, the OSAVO will arrive at the OLSF some 30 minutes after initiation of Pre-Launch Checkout procedures).
137b	T-20	LSS	Stores LSS expendables aboard OLV.
138	T-5	PM	Notifies LCD of readiness for pre-launch C/O of the OLV.

PART II - PRE-LAUNCH CHECKOUT

Pre-launch Checkout is the automatic check of the subsystems in the Orbital Launch Vehicle on an integrated basis. Essentially it is the same as that conducted by the automatic checkout equipment during the checkout procedure; however, all systems are energized simultaneously and operation is verified in a sequential computer routine.

In developing these procedures, it was assumed that:

(1)   The crew and passenger carrier, lunar cargo modules, and propellant tanks were placed in Earth orbit at a pre-scheduled time such that supplies and equipment were available to the orbital checkout crew as needed.

(2)   The Lunar Ferry was re-fueled during the Major Subsystems Checkout and cargo was properly placed aboard.

(3)   The personnel to be transferred to the moon, including the Lunar Ferry flight crew, were placed aboard an OLSF to remain there while the vehicle was being checked-out and serviced.

It is estimated that pre-launch checkout will require approximately 6.33 hours for execution.

Sequence No.	Time From	To	Resp.	Task
1a	T-380	T-375	LCD	Notifies CPA to program automatic checkout equipment.
1b	T-380	T-360	CPA	Programs computer for integrated system checkout (C/O).
1c	T-380	T-360	LSS	Performs accurate inventory of supplies.
2	T-370	T-360	OSAVO	Performs close-in rendezvous to Orbital Launch Support Facility (OLSF).
3	T-360	T-350	OSAVO	Performs hard docking to OLSF.
4	T-350	T-320	OSAVO	Dispatched with remote control vehicle for exterior inspection of OLV. Note: PM now occupied.
5a	T-335	T-320	PM	Prepares fuel and propulsion systems for automatic C/O.
5b	T-335	T-320	CS	Prepares communications and radar systems for automatic C/O.
5c	T-335	T-320	GS	Prepares navigation, guidance and attitude control systems for automatic C/O.
6a	T-330	T-320	ES	Prepares electrical power systems for automatic C/O.
6b	T-330	T-320	LSS	Prepares the ECS for automatic C/O.
7a	T-320	T-315	OSAVO	Notifies Launch Control Director (LCD) of readiness to accomplish inspection.
7b	T-320	T-315	CS	Notifies the LCD of readiness for integrated systems C/O.
8a	T-315	T-270	CPA	At direction of LCD starts checks. - Monitors results of C/O on OLSF displays and records results.
8b	T-315	T-270	OSAVO	Performs inspection of exterior with remote inspection vehicle.
8c	T-315	T-270	ES LSS GS CS PM	Monitor displays of OLV systems tests. Repairs, adjusts, calibrates, rechecks as required.

Sequence No.	Time From	To	Resp.	Task
9a	T-270	T-120	PM	Perform or (assist in) final top-off of systems.
	T-270	T-120	ES	Perform final visual inspection.
	T-270	T-120	LSS	Performs general clean-up.
	T-270	T-145	GS	Stores debris in OSAV for transfer to OLSF.
9b	T-270	T-210	CPA	Summarizes results of C/O analysis. - Transmits results to GOSS.
9c	T-270	T-240	OSAVO	Returns remote control inspection vehicle to Orbital Launch Support Facility.
9d	T-270	T-250	CS	Performs communication check with GOSS.
10	T-250	T-120	CS	Performs final visual inspection of OLV interior systems for which responsible. Assists in topping off ECS, RCS, propulsion fuel systems as required. Assists in general clean-up of OLV interior. Stores debris in OSAV for transfer to OLSF.
11a	T-240	T-210	OSAVO	Translates to OLV in OSAV.
11b	T-240	T-185	GOSS	Performs analysis of C/O results.
12	T-210	T-200	OSAVO	Performs close-in rendezvous.
13	T-200	T-190	OSAVO	Performs hard docking to OLV.
14	T-190	T-120	OSAVO	Assists C/O crew as required in clean-up, topping and storing debris in OSAV.
15	T-155	T-150	GOSS	Confirms C/O with LCD.
16	T-150	T-145	LCD	Receives confirmation of C/O results from GOSS.
17a	T-145	T-140	LCD	Directs Guidance Specialist (GS) to insert launch window data in OLV guidance computer.
17b	T-145	T-130	GS	Inserts launch window data in OLV guidance computer per direction of LCD.

Sequence No.	Time		Resp.	Task
	From	To		
18	T-140	T-120	LVP*	Loads lunar passengers in crew and passenger carrier for translation to OLV.
19	T-130	T-120	LCD GS GOSS	Confirm launch window data.
20a	T-120	T-115	LCD	Receives notification from CS of readiness of C/O crew to depart from OLV.
20b	T-120	T-90	LVP	Translates to OLV via crew and passenger carrier.
21	T-115	T-90	C/O Crew	Load aboard OSAV.
22a	T-90	T-60	C/O Crew	Translate to OLSF.
22b	T-90	T-80	LVP	Performs close-in rendezvous maneuver.
23	T-80	T-70	LVP	Performs hard docking to OLV.
24	T-70	T-50	LVP	Unloads personnel.
25a	T-60	T-50	C/O Crew	Performs close-in rendezvous maneuver to OLSF.
25b	T-50	T-20	LVP	Translates via crew and passenger carrier to OLSF.
26	T-50	T-40	C/O Crew	Performs hard docking to OLSF.
27	T-20	T-10	LVP	Performs close-in rendezvous maneuver to OLSF.
28	T-10	T-0	LVP	Performs hard docking to OLSF and stands by for countdown.

*Logistic Vehicle Pilot

LCD	Launch Control Director (OLSF)						
OSAVO	Orbital Support Assy.Veh.Opr.						
ES	Electrical Specialist						
LSS	Life Support Specialist						
CS	Electronics Specialist						
GS	Guidance and Nav. Specialist						
PM	Propulsion-Mechanical Special.						
CPA	Checkout-Programmer /Analyst						
LVP	Logistic Vehicle Pilot						
GOSS	Ground Operated Support System						

                          1   2   3   4   5   6

■ Basic Task
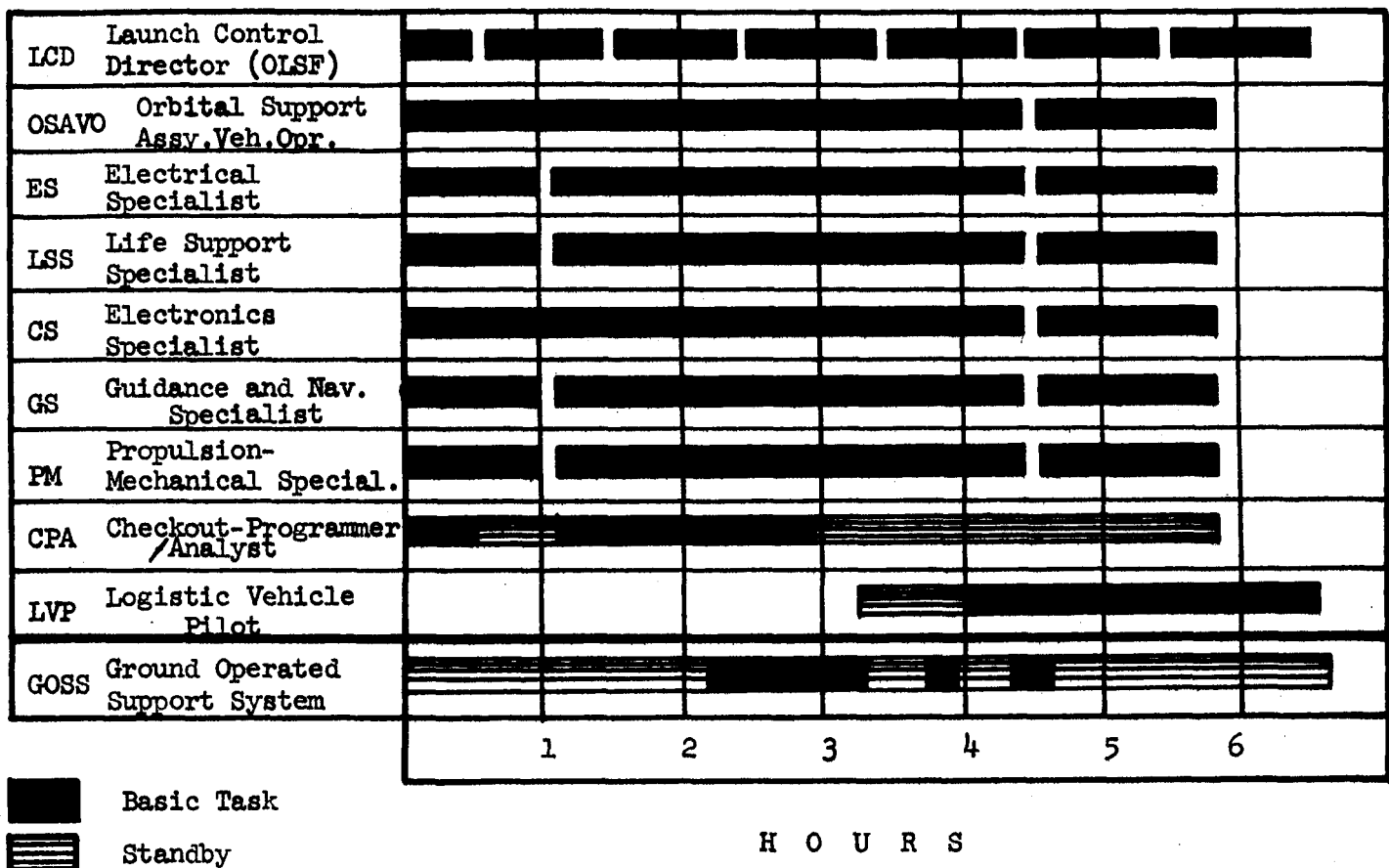
≡ Standby

H O U R S

The approximate checkout crew manhours required to conduct the pre-launch checkout of the Lunar Ferry (excluding GOSS) equals:

                    Basic Task - 44.33
                    Standby   - 4.25

                       Total   = 48.58 hours

FIGURE B.3-2:
PRE-LAUNCH CHECKOUT
PERSONNEL UTILIZATION - TIME LINE

B-58

PART III - COUNTDOWN

Countdown procedure consists primarily of confidence checks performed by the Flight Crew and is a repetition of checks conducted by the checkout crew during the pre-launch checkout. The checks consist of visual and automatic checks of vehicle subsystems in addition to observation of flight parameter displays as the launch time approaches.

It is assumed the three flight crew members and the lunar base crew are all aboard the Lunar Ferry and that the vehicle has been fully serviced, ready for countdown.

It is estimated the countdown will require approximately 3.08 hours to complete.

Sequence No.	Time From	Time To	Resp.	Task
1a	T-185	T-165	PC	Inspects flight displays and controls.
1b	T-185	T-155	PE	Visually inspects: - Electrical power systems. - Guidance and navigation system. - Accessible Reaction Control System Components. Operates the communications and radar systems. Checks the fuel quantity displays.
1c	T-185	T-155	PS	Visually inspects the Environmental Control System (ECS) displays - Atmospheric composition indicators - LOX and nitrogen supply indicators - Humidity control indicators - Coolant system indicators - Radiation detection system indicators - Cabin leakage indicators Visually inspects: - The zero "G" commode - The personal hygiene facilities - The food refrigeration and storage facilities. Checks the potable water supply.
2	T-165	T-145	CPA	Programs checkout equipment aboard OLSF.

Sequence No.	From	To	Resp.	Task
3a	T-155	T-145	PE	Performs self-check of on-board computer.
3b	T-155	T-145	LCD	Directs C/O crew to prepare for automatic checkout.
4	T-140	T-135	PC	Notifies Launch Control Director (LCD) of vehicle readiness for automatic C/O from OLSF.
5a	T-145	T-100	CPA	Starts checks at direction of LCD. - Monitors progress of checks.
5b	T-145	T-100	C/O Crew	Assist CPA in analysis as required. - Monitors displays as required.
6a	T-100	T-70	CPA	Summarizes C/O data and transmits to GOSS per schedule.
6b	T-100	T-80	LCD PC	Confirm OLV C/O results with each other.
7	T-80	T-70	LCD	Notifies PC and GOSS of vehicle status for lunar flight. - Makes go- no go decision.
8a	T-70	T-55	PC	Maneuvers Lunar Ferry into launch orientation.
8b	T-70	T-45	PE	Verifies status of guidance, navigation, attitude control, communications, and radar systems.
8c	T-70	T-45	PS	Verifies status of ECS.
9	T-55	T-45	PC	Verifies status of launch computer settings, electrical power systems, RCS, and stabilization system.
10	T-45	T-35	GOSS PC	Transmits launch parameters to PC. - Verifies vehicle orbital characteristics.
11	T-35	T-25	PC	Verifies launch computer settings.

Sequence No.	From	To	Resp.	Task
12a	T-25	T-15	PC	Starts nuclear engines. - Stabilizes engine at minimum power setting.
12b	T-25	T-15	PE	Verifies status of electrical power systems. Verifies functioning of engine and fuel systems.
13	T-15	T-10	PC	Rechecks launch computer settings.
14	T-10	T-05	PC	Verifies vehicle orientation; notifies flight crew and passengers to standby for launch.
15	T-05	T-0	PC	Executes launch.
16	T-0	T+20	GOSS	Monitors and keeps PC informed of launch trajectory.

			HOURS		
PC	Pilot Commander Lunar Ferry				
PE	Pilot Engineer Lunar Ferry				
PS	Pilot Scientist Lunar Ferry				
LCD	Launch Control Director				
CPA	Checkout-Programmer/Analyst				
OSAVO	Orbital Support Assy. Veh. Opr.				
	Orbital Checkout Crew (5)				
GOSS	Ground Operated Support System	1	2	3	

HOURS

■ Basic Task
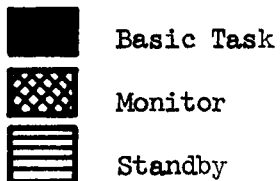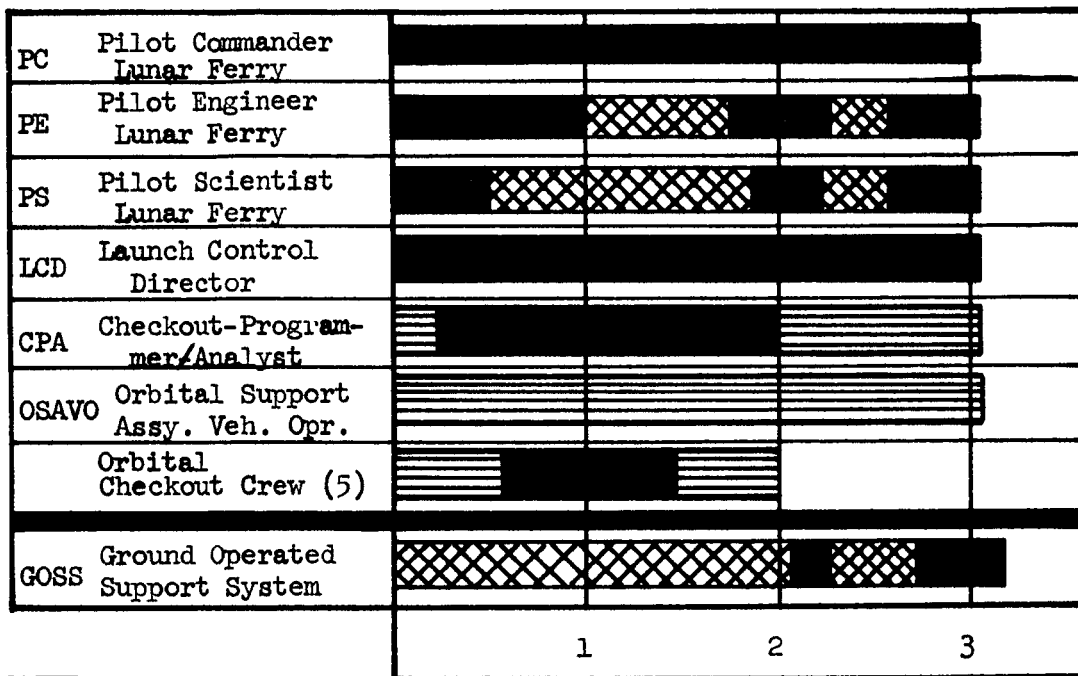
▨ Monitor

☰ Standby

The approximate total checkout crew manhours required for the count-down operation (excluding GOSS) equals:

Basic Task - 16.16
Monitor   - 2.83
Standby   -   9.33

Total   = 28.32

FIGURE B.3-3:
COUNTDOWN - PERSONNEL UTILIZATION - TIME LINE

APPENDIX C

FUNCTION AND TASK ANALYSIS OF
MAJOR OPERATIONS AND EVENTS

- MARS FLYBY VEHICLE

The purpose of this analysis is to estimate the man/machine tasks, number of personnel and accumulated time, and manhours required to perform all the major operations and events defined in Appendix A.1 in support of launching the Mars Flyby vehicle from Earth orbit. Where considered appropriate, the results of the Lunar Ferry Checkout and Countdown Procedures (Appendix B.3) have been incorporated in this analysis, suitably modified, to account for anticipated differences in the vehicle subsystems. Reference should be made to Appendix B.2 for an explanation of the format used.

For the purpose of estimating the time required in assembly orbit to perform the many supporting operations, it is assumed that all supplies, vehicle segments, auxiliary vehicles, etc. are readily available to the orbital checkout crew as they were needed. The effects of the availability of Earth launch pads and vehicles, realistic Earth launch rate, etc., on the total time to perform the major operations are discussed in Volume II.

The results of the analysis presented herein are summarized as follows:

Total manhours required for performing all major
operations and events.   ▪ 427
Total accumulated (consecutive) hours required.   ▪ 101
Total Orbital Checkout Personnel required.   ▪ 9
Total Mars Flyby Mission Vehicle Flight Crew   ▪ 3
    (Will assist in countdown operations only.)

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — OAMV Without Manipulators	OAMV With Manipulators	Personal Carrier	Boot Suit and Extravehicular Tools/Equipment	Boot Suit and Intervehicular Tools/Equipment	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	Accumulated Total	Man-Minutes Per Function	(7) EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
1. Launch Mars Flyby Vehicle to earth orbit (manned by c/o crew of 3).	a. Launch to parking orbit.	Ground initiated												All controls for this basic operation are executed from the ground.
	b. Separate & jettison fairing & escape prop.	Ground controlled.												Time to perform this basic operation is not charged for the time required for checkout crew to execute their functions.
	c. Transfer to assembly orbit.	Ground controlled.										OLSF could serve as focal point for assembly & checkout operations.		
	d. Activate vehicle guidance system.	Ground controlled												
2. Without OLSF Launch orbital support vehicle to earth orbit (w/additional c/o crew as req'd).	a. Same as 1a													Remarks in (1) above apply.
	b. Same as 1b													
	c. Same as 1c	Ground controlled												
	d. Transfer of orbital support veh. and crew from final position in assembly orbit to mission vehicle.	SOP piloting techniques.			X			1						With no OLSF available, the support vehicle would proceed from its "arrival position" in assembly orbit to the mission vehicle (the "arrival position" is assumed to be within 1,000-2,000 yds. of the latter).
3. With OLSF transfer of orbital support vehicle to mission vehicle.	a. Transfer checkout crew from OLSF to attached support vehicle.	Crew will exit OLSF through the pressurized passageway to support vehicle.			X			1						Note: Even though not necessarily alluded to in certain cases, the support vehicle will always be immediately available (generally in close proximity) during assembly, checkout, and launch of the mission vehicle.
	b. Separate support vehicle from OLSF.	SOP pilot techniques assisted by second crewman who will secure the hatch.			X			2						
	c. Transfer support vehicle and checkout crew to mission vehicle.	SOP pilot techniques			X			2						The time of transfer from OLSF to the mission vehicle is assumed to be the same (and would occur in lieu of) that function shown in 2d.

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Manip. without OS/V	Manip. with OS/V	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RMU	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	(7) Man-Minutes Per Function	(7) EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
4. Rendezvous & lock support veh. (whether w/ OLSF or Earth boost) w/ mission Vehicle.	a. Perform rendezvous maneuver. (Note: it is assumed the mission vehicle will be stabilized, i.e., will not be tumbling.)	SOP pilot rendezvous techniques	x							1	10	10	10			This is the "close-in" maneuver. All times will be accumulated from this function onward. Whether the support vehicle is boosted from earth or arrives from the OLSF, it is assumed this function would require about the same amount of time for completion. (All time will start w/ this function)
	b. Hard dock support vehicle w/ mission vehicle.	SOP hard dock maneuver techniques. Second crewman will manually prepare hatch.	x							2	10	20	20			Support vehicle will probably be docked w/ a service module. Service module to prepare it for join-up w/ spoke.
	c. Workers will exit support veh. for purpose of inspecting entire mission vehicle.	Worker will don pressure suit and AMU; enter hatch, close door and depressurize; open outer door and exit vehicle. He may take certain special tools w/ him.				x	x			4	20	40	80			It will be necessary to inspect entire veh. for any damage, particularly the join-up areas. This function is particularly important if veh. has been in orbit for any extended length of time (i.e., for several days).
	d. Externally inspect vehicle.	Primarily visual inspection; external lighting & some tools will be req'd.				x	x			4	140	180	560			Two of the 4 workers will remain outside to assist in, and observe erection operations to follow.
	e. Internally inspect command & service modules.	Primarily visual; inspect for damages, displacement of items, equipment, etc., some re-arrangement & adjustment of equipment may be req'd.						x		2	80	180*	160*			This function will be performed concurrently while external inspection is being carried out. Time shown includes that necessary for one crewman to exit and re-enter the support vehicle.
	f. Internal crewman will deactivate all RF equipment.	Most likely to be accomplished by manual switching mechanism in command module.								1	5	180	05			This task performed at completion of internal inspection of command module; no additional time required.
	g. Remove pyrotechnics	Manual performed by external crew during inspection.				x	x			2		180				Task performed concurrently during inspection; no additional time required.

*Time shown in this column will always be the same as the preceding item, when both functions are performed concurrently.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Min.)			(7) EFFECTS OF		(8) REMARKS
			Manipulators OS&V Without	Manipulators OS&V With	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	IMU		Per Function	Total Accumulated	Man-Minutes Per Function	HAVING OLSF	NOT HAVING OLSF	
	h. Activate RF equipment (as req'd).	Same as in 4f above.								1	05	185	05			Equipment must be activated to facilitate erection operations.
5. Perform mission vehicle erection operations.	a. Prepare command module for "plugging into" spoke.	Astronaut will activate shape charge system, freeing command module (and retro unit) from service module adapter. He will then maneuver command module as req'd by use of retro propulsion system.						x		1	30	215	30			Assumptions: (1) Command module can be freed from service module adapter by activation of shape charge; (2) pilot astronaut can maneuver stabilized command module by use of a reserviceable retro propulsion system. Command module will most likely be depressurized during this function.
	b. Rotate first spoke 90° and lock into position in preparation for command module "plug in".	This function could be done by a manned orbital assembly support vehicle with manipulators; pilot would maneuver. Extravehicular worker would manually free spoke from its secured position for launch.		x		x	x			3	60	275	180			Pilot of orbital assembly support vehicle (OS&V) can move spoke into place. Once in place, spoke is locked securely by combined efforts of internal and extra-vehicular workers.
	c. Join command module to first spoke.	Pilot would maneuver command module by use of retro propulsion and reaction control system and effect join-up by hard dock type maneuver.								3	30	305	90			The locking mechanisms alluded to in 5b would probably be used. A minimum of one pilot plus 1 external and one internal worker are required to perform alignment and joining operations.
	d. Rotate second spoke 90° (w/ service module attached) and lock into position.	Same as in 5b above.		x		x	x			3	60	365	180			Remarks in 5b apply.

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — OSAV Without Manipulators	OSAV With Manipulators	Personnel Carrier (OMV)	Soft Suit and Tools/Equipment Extravehicular	Soft Suit and Tools/Equipment Intervehicular (RGU)	(5) No. of Men Required in Orbit	(6) Per Function	Total Accumulated	Min-Minutes Per Function	(7) HAVING OLSS	NOT HAVING OLSS	(8) REMARKS
	e. Detach service module from launch position on spoke.	This task will require the combined efforts of the OSAV operator and extra-vehicular workers. The latter can manually release the service module and assist in connecting up the OSAV.		x	x	x		3	30	395	90			Note: It is assumed the extra-vehicular worker can remain outside in the void of space for 4 consecutive hours of operation at which time he must return to a pressurized environment for resupply of his life support system and to re-establish periodic exit and re-entry or such OSAV personnel (as req'd) should not add to the over-all accumulated time.
	f. Join service module to spoke.	Pilot, operating OSAV which has been securely attached to the service module, maneuvers the entire unit into position for join-up. Extravehicular workers assist in alignment functions and in manually securing the unit once it is in place.			x	x		3	60	455	180			Extravehicular workers can be utilized to assist OSAV pilot in not only alignment functions, but also in secur-ing the opposite sides of the spoke simultaneously, and in confirming the job is proper-ly done
	g. Effect pressuriza-tion seals at fold-lines.	This function can be carried out by welding each joint, completely around the spoke. It appears desirable that joints be welded from the outside.			x	x	x	4	480	935	1920			There are 4 such joints when one considers both the joining of each spoke to the hub and to each module (command and service).
	h. Pressurize spokes and all seals and check for leaks.	Operation of manual valve(s) releasing atmosphere from vehs internal source into spokes (atmosphere contains a given amount of helium). Extra-vehicular workers, using helium mass spectrometers, will check seams for leaks.			x	x	x	2	120	1055	240			From this point onward, the crew should have internal pres-surized atmosphere in which to work. They will perform in depressurized suits, however, (in the interest of safety), until further system checks have been made.
	i. Secure all connect-ions (as req'd) be-tween command module and spoke as well as service module and spoke.	Manual (internal) join-up of a given number of electrical, mechanical and hydraulic lines, wires, and other such connect-ions will be required.			x	x	x	4	480	1535	1920			The extent of such operations is most difficult to estimate. It is assumed that at least 4 men are required -- two assim-lated with each module. Extravehicular activity may also be required.

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Min.)			(7) EFFECTS OF		(8) REMARKS
			OSAV Without Manipulators	OSAV With Manipulators	Personnel Carrier	AMU	Extravehicular Soft Suit and Tools/Equipment	Intervehicular Soft Suit and Tools/Equipment	RMU		Per Function	Accumulated Total	Man-Minutes Per Function	HAVING OLSF	NOT HAVING OLSF	
	j. Secure all connections (as req'd) between spokes and center hub.	Same as noted in 5j above w/ less connections being req'd.					x	x		4	360	1895	1440			Extravehicular activity may also be required.
	k. Reposition internal arrangement of command module.	Task will be accomplished primarily by manual operations on the part of the crew. It is mandatory that mission vehicle design facilitate the performance of this task in the interest of simplicity and reliability.				x	x	x		4	900	2795	3600			The internal arrangement of the (Apollo) command module, i.e., the seats, displays, etc., must be entirely re-arranged for the trans-Mars mission. It is assumed that this will be relatively easy to accomplish, requiring no special tools, techniques, etc.
	l. Assemble elevator in spoke assembly.	This task will be executed largely by manual operations and should consist simply of securing elevator to track and connecting controls.						x		4	120	2915	480			This should be a relatively simple task since track, fittings, etc., will have been previously fabricated and secured in place.
6. Perform checkout of mission vehicle.	a. Activate and perform checkout on all veh. subsystems and equip. Verify status of all subsystems.	All functions and tasks described in Checkout and Countdown Procedures, Appendix B.3.		x		x	x	x		4.5	1915	4830	8618			Subsystems checked out include Electrical Pwr. - 240 min. ECS System - 220 min. Food Prep. - 295 min. Nav. & Guid. - 125 min. Comm. Sys. - 110 min. Lighting - 120 min. Propulsion - 805 min.
	b. Call ground for next payload.	Voice communications								1	05	4835	05	OLSF would perform this function.	Function would be performed from support vehicle.	
7. Launch propellant tanker No. 1 to earth orbit.	Same as in Item 1a, 1b, 1c.	See Item 1a, 1b, 1c.														All functions ground controlled. Time to perform this operation is not charged to accumulated total checkout time.
8. Rendezvous & dock propellant tanker to mission vehicle.	a. Perform rendezvous maneuver.	Crew in support veh. will remotely operate propulsion system on propellant tank to effect rendezvous. Close-in rendezvous effected w/ aid of orbital assembly support vehicle.		x						2	30	4865	60			It is assumed ground control would place tanker in orbit within 1,000-2,000 yds. of mission veh. OSAV could be used to retrieve tanker if its propulsion system malfunctioned.

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	OSAV Without Manipulators	OSAV With Manipulators	Personnel Carrier (AMU)	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment (RMU)	(5) No. of Men Required in Orbit	(6) Per Function	(6) Accumulated Total	Man-Minutes Per Function	(7) HAVING OLSF	(7) NOT HAVING OLSF	(8) REMARKS
	b. Dock propellant tanker to mission propulsion module.	Pilot manipulation of OSAV assisted by extravehicular workers for connecting the two units, for aligning, etc.		x		x		3	30	4895	90			
	c. Position and connect propellant transfer lines and confirm status.	Continuation of operation 8b. Manual securing and checking of connections will be req'd.		x		x	x	3	40	4935	120			Time for this task will largely depend upon the extent of manual operations in securing propellant lines.
	d. Call for next payload.	Voice communications						1	05	4940	05	OLSF would perform this function.		
9. Repeat of basic operations 7 and 8.	Same as in Item 7 and 8 above less function 8d.			x		x		2.6 (avg)	105	5045	275			Total time and average number personnel shown in Items 7 & 8 entered here.
10. Perform re-check of mission vehicle systems.	Activate all mission vehicle systems and perform "pre-flight" check to verify vehicle ready for fuel transfer.	Description given elsewhere in report.		x		x	x	5	90	5135	450	OLSF would investigate and perform recheck.		In reality, several hours may have passed between assembly of tanker No. 1 & 2 to the mission veh. due to limitation in Earth launch capabilities. Thus, the need for checking mission veh. subsystems becomes even more important.
11. Perform propellant transfer from propellant tankers to mission vehicle Earth escape booster.	a. Initiate propellant transfer operation.	Pilot will initiate vehicle acceleration as req'd (see remarks) while second crew member will operate control initiating fuel transfer.						2	10	5145	20			From the two connected fuel tanks, approximately 354,000 lbs. of liquid O_2 must be transferred.
	b. Observe propellant transfer areas for possible leakage; continue transfer function.	Extravehicular workers will probably have to be stationed externally to observe entire operation.			x	x	x	4	50	5195	200			Tentative findings for transferring fuel indicate the entire mass (mission vehicle and connected tanks) must be accelerated either linearly or angularly.
	c. Observe vent lines for proper venting.	Same as in 11b above.				x		2		5195				These tasks performed concurrently with 11b.
	d. Monitor propellant mass transferred; terminate operation as required.	Internal operators will monitor via instrumentation presentation(s).						2		5195				

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Manipulators Without OS/V	Manipulators With OS/V	Personnel Carrier (AMU)	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment (EMU)	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	Min-Minutes Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	e. Terminate entire transfer operation and verify fueled vehicle status.	Pilot will terminate vehicle acceleration and will "close" fuel transfer switch.					x	2	05	5200	10			
12. Separate propellant tankers.	See basic operation No. 10a and b, Function and Task Analysis, re: Lunar Ferry.			x	x	x		3	95	5295	285			
13. Perform pre-launch checkout of mission veh.	a. Deactivate all RF systems. b. Activate pyrotechnic system. c. Activate all req'd systems. d. Confirm ephemeris data.	By manual operation of switches, guidance data confirmed by initiating contact w/ ground (or OLSF) and observing "read-out" data.						2	20	5315	40			
	e. Conduct checkout of mission vehicle. f. Complete c/o - confirm status of veh.	Functions described elsewhere in report. See Part II - Pre-Launch Checkout, Appendix B.3.	x		x	x	x	7 (avg)	380	5695	2660	OLSF would have major role in c/o, in analyzing results, etc.	Support vehicle would possess the equipment to perform the c/o task.	This pre-launch c/o time is assumed to be essentially the same as that for Lunar Ferry.
	g. Position support vehicle for servicing mission veh.	This may require a hard dock maneuver; in any case, support vehicle must be "docked" in close proximity to mission veh.	x					2		5695				Time for this function included in Item e and f.
	h. Connect service lines from support vehicle to mission vehicle and top off all systems as required.	Lines may be manually connected from the support to the mission vehicle; some may be by external connections while others may be joined via the hard dock passageway.	x		x	x	x	4		5695				Servicing of such systems as O$_2$, N$_2$, H$_2$O, hydraulic, etc., will be required.
	i. Disconnect all servicing lines & verify vehicle ready for orbital launch & receipt of mission crew.	Crew will manually shut-off all refurbishing supply line as required and disconnect same. They will verify vehicle mission ready.	x		x	x	x	4		5695				Time for this function included in Item e and f.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Min.)		(7) Min-Minutes Per Function	EFFECTS OF		(8) REMARKS
			OS-V Without Manipulators	OS-V With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RMU		Per Function	Total Accumulated		HAVING OLSF	NOT HAVING OLSF	
14. Transfer orbital support vehicle to parking orbit.	a. Separate support veh. from mission vehicle if hard docked (see Item 13g above).	SOP for pilot separation maneuver.	x							2	10	5705	20			Note: Support vehicle must wait in readiness for launch of the mission veh. If no OLSF available, support veh. would be so positioned in parking orbit to provide television coverage of mission veh. launch & to provide emergency support as may be req'd. If OLSF available, it would provide television coverage of launch operations.
	b. Transfer support vehicle to parking orbit.	SOP for piloting	x							2	40	5745	80	If OLSF available, support vehicle would be hard docked w/ facility. C/o crew would remain in facility.		
15. Launch crew carrier to Earth orbit (manned by mission crew)	a. Notify ground of readiness to receive flight crew.	Voice communications								1	05	5745	05	OLSF would normally perform this command function.	Function would be performed from support vehicle if no OLSF available.	This task performed concurrently with 14b, thus, no additional time req'd.
	b. Launch to parking orbit. c. Separate and jettison fairing and launch escape propulsion. d. Transfer to assembly orbit. e. Separate payload & boost stage.	These functions will probably be performed by ground control w/ pilot override as deemed advisable.										5745				This function could be scheduled such as to preclude loss in checkout time. Thus, it is assumed the mission crew and carrier are available in Earth orbit when needed.
16. Rendezvous and dock crew carrier with mission vehicle.	a. Perform rendezvous maneuver.	Pilot of crew carrier will position vehicle from arrival position in orbit to the mission vehicle.			x							5745				This function performed by mission veh. flight crew who are boosted into orbit aboard the carrier.
	b. Hard dock crew carrier w/ mission vehicle.	SOP hard docking technique. Second crewman will prepare hatch.			x							5745				This function performed by mission vehicle flight crew. No additional time req'd as this function performed following 14a assuming 15a performed early.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) OSV w/o Manip.	OSV w/ Manip.	Personnel Carrier (AMU)	Extravehicular Soft Suit and Tools/Equipment	Intervehicular Soft Suit and Tools/Equipment (EMU)	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	Total Accumulated	(7) Man-Minutes Per Function	EFFECTS OF HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	c. Mission (flight) crew transfer to mission veh., remaining checkout crew in mission vehicle transfer to crew carrier.	Crews will transfer through pressurized hatch.			x					5745				The number of c/o crew to transfer to carrier would probably be no more than (5); crew will transfer any equipment as req'd. No additional time req'd beyond 14b.
17. Separate crew carrier and transfer to parking orbit.	a. Separate carrier veh. from mission veh.	SOP pilot separation techniques			x			2	10	5755	20			Same as in Remarks, Item 14. Substitute words "crew carrier" for support vehicle.
	b. Transfer crew carrier to parking orbit.	SOP piloting techniques.			x			2	40	5795	80	Same note as in 14b applies. Substitute word "crew carrier" for support veh.		
18. Mission crew conduct mission readiness test.	a. Perform mission readiness test -- flight check of all systems - confirm status.	Flight crew will conduct pre-flight check prior to initiating countdown.			x	x	x	3	60	5855	180	OLSF will contain necessary c/o equipment for providing stimuli and for evaluating results.	Otherwise, support vehicle would contain the necessary c/o equipment.	Pre-flight checks will include internal and external visual inspection.
	b. Confirm ephemeris data & veh. attitude for launch.	Communications w/ ground or OLSF (as applicable).						2	10	5865	20			
	c. Confirm mission vehicle ready for c/d.	Tasks described elsewhere in report.			x	x	x	1	05	5870	05	Contact OLSF or support veh. as applicable.		
19. Initiate final countdown.	a. Start countdown of mission vehicle.	Functions described elsewhere, see Appendix B.3.						6	05	5875	30	OLSF would initiate.		See Part III, Countdown, Appendix B.3.
	b. Confirm readiness status of auxiliary vehs. for support rescue, observation of launch, etc.	By voice communications w/ such auxiliary vehs. or the OLSF.						1	05	5880	05			Pilot of mission vehicle would confirm.
	c. Complete countdown to automatic seq. portion.	Functions described elsewhere.						6	185	6065	1110			Checkout and mission vehicle crews monitor from this point on.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, SERVICING, CHECKOUT AND LAUNCH OF MARS FLYBY VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — O&AV Without Manipulators	O&AV With Manipulators	AMU Personnel Carrier	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	IMU	(5) No. of Men Required in Orbit	(6) Time Req'd (Min.) Per Function	Accumulated Total	Man-Minutes Per Function	(7) EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	d. Initiate countdown "hold" - synchronize launch time w/ automatic launch count.														Automatic function.
	e. Initiate automatic countdown sequence.								6	01	6066	06			Automatic
20. Mission vehicle launch.	a. Initiate launch sequence.								6	01	6067	06			Automatic
	b. Orbit launch								6						Automatic
	c. OLSF or support vehicle and crew carrier monitor launch & confirm injection.	T.V. monitoring visual observations voice communications.	x						3	10	6077	30	OLSF will confirm to ground.	Support vehicle and/or crew carrier will confirm to ground.	
							TOTALS				6077	25,625			

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APPENDIX D

FUNCTION AND TASK ANALYSIS OF MAJOR OPERATIONS AND EVENTS
(ESTIMATED)
- MARS CAPTURE VEHICLE

Based on the combined results of the Function and Task Analyses of the operations in support of the Lunar Ferry, the Mars Flyby Mission, and in particular, the Mars Landing (Convoy) vehicles, an estimate was made of the time required to perform each major operation to service, checkout, and launch the Mars Capture Vehicle. As in the case of the other analyses, it is assumed that all equipment, tools, supplies, tankers, auxiliary vehicles, etc., were readily available in the assembly orbit as needed by the checkout crew.

On the following pages, the Major Operations, as presented in Appendix A.2, have been extracted and an estimate has been made of the total time and manhours required to accomplish each task. The results are shown as follows:

Total manhours required for performing all Major Operations and Events	- 3,229
Total accumulative (consecutive) hours required	- 346
Total orbital checkout personnel required	- 14
Total Mars Capture Vehicle Flight Crew (will assist in countdown operations only)	- 6

MAJOR OPERATIONS FOR MARS CAPTURE VEHICLE
TIME AND MANHOURS REQUIRED FOR EXECUTION

Major Operation No.	Description of Operation	Required Hours	Required Manhours
1	Launch M-3 and M-4 stages and Life Support Section (LSS) to Earth Orbit Note: LSS is manned.	0.00	0.00
2	Conduct checkout of M-3 and M-4 stages and LSS.	60.00	480.00
3	Launch Support Vehicle No. 1	.84	1.52
4	Rendezvous and dock support vehicle with LSS	1.09	3.51

Major Operation No.	Description of Operation	Required Hours	Required Manhours
5	Launch M-2 stage to Earth orbit.	0.00	0.00
6	Rendezvous and dock M-2 stage to M-3 stage.	2.50	6.50
7	Assemble M-2 stage to M-3 stage.	30.08	300.08
8	Perform checkout of M-2 stage.	10.00	80.00
9	Launch M-1B stage to Earth orbit.	0.00	0.00
10	Rendezvous and dock M-1B stage to M-2 stage.	2.50	10.00
11	Assemble M-1B stage to M-2 stage.	30.08	300.08
12	Perform checkout of M-1B stage.	10.00	80.00
13	Launch M-1A stage to Earth orbit.	0.00	0.00
14	Rendezvous and dock M-1A stage to M-1B stage.	2.50	10.00
15	Assemble M-1A stage to M-1B stage.	30.08	300.08
16	Perform major checkout of complete mission vehicle.	45.00	540.00
17	Launch Support Vehicle No. 2	3.17	9.34
18	Rendezvous and dock support vehicle to ISS	1.33	3.99
19	Perform service functions - refurbish mission vehicle systems.	15.00	120.00
20	Launch Propellant Tanker No. 1 to Earth orbit.	0.00	0.00
21	Rendezvous and dock propellant tanker No. 1 with mission vehicle.	1.50	6.00
22	Position tanker module No. 1 and connect service lines.	1.00	6.00
23	Launch Propellant Tanker No. 2 to Earth orbit	0.00	0.00
24	Rendezvous and dock propellant tanker No. 2 with mission vehicle	1.50	6.00

Major Operation No.	Description of Operation	Required Hours	Required Manhours
25	Position tanker module No. 2 and connect service lines.	1.00	6.00
26	Launch Propellant Tanker No. 3 to Earth orbit	0.00	0.00
27	Rendezvous and dock propellant tanker No. 3 with mission vehicle.	1.50	6.00
28	Position tanker module No. 3 and connect service lines.	1.00	6.00
29	Perform checkout of mission vehicle.	2.00	20.00
30	Perform propellant transfer operation.	1.25	10.00
31	Separate empty propellant tankers from mission vehicle.	1.00	10.00
32	Perform checkout of mission vehicle.	35.00	420.00
33	Launch Support Vehicle No. 3	3.17	9.34
34	Rendezvous and dock support vehicle with LSS.	1.33	3.99
35	Perform service functions - refurbish mission vehicle systems.	15.00	120.00
36	Launch Mission Crew Carrier - manned by mission crew.	0.00	0.00
37	Rendezvous and dock mission crew carrier with LSS.	1.50	6.00
38	Separate Support Vehicles No. 1, 2, and 3, and Crew Carrier - manned by checkout crew.	.33	.66
39	Transfer support vehicles and crew carrier to parking orbit.	.50	1.00
40	Mission crew conduct mission readiness test.	10.00	100.00
41	Conduct pre-launch operations and countdown.	10.00	120.00
42	Initiate final countdown.	10.00	120.00

Major Operation No.	Description of Operation	Required Hours	Required Manhours
43	Mars Capture Mission - orbital launch.	.67	4.02
44	Support vehicles and crew carrier return to Earth.	.50	3.00
	TOTALS=	345.92	3,229.00

APPENDIX E

FUNCTION AND TASK ANALYSIS OF MAJOR OPERATIONS AND EVENTS

MARS LANDING CONVOY

The purpose of this analysis is to estimate the man/machine tasks, number of personnel, accumulated time, and manhours required to perform all the major operations and events, as defined in Appendix A.4, in support of launching the Mars Convoy vehicles from Earth orbit. Where considered appropriate, the results of the Lunar Ferry Checkout and Countdown Procedures (Appendix B.3) have been incorporated in this analysis suitably modified to allow for anticipated differences in vehicle subsystems and numbers of vehicles. The analysis assumes that the subsystems of the Lunar Ferry and the crew vehicle of the Mars Landing Mission would be quite similar since they come into being at about the same time period (1978 and 1982, respectively). Reference may be made to Appendix B.2 for an explanation of the format used.

For the purpose of estimating the time required (in assembly orbit) to perform each supporting operation, it is assumed that all supplies, vehicle segments, refueling tankers, auxiliary vehicles, etc., are readily available to the orbital checkout crew as needed. In some cases, smaller items of equipment, or supplies, may be located in the nearby OLSF; this facet does not appreciably affect the results of the analysis.

The effects of the availability of Earth launch pads and vehicles, realistic Earth launch rates, etc., on the total time required to prepare and launch the convoy are discussed in Volume II.

The results of the analysis as reported herein may be summarized as follows:

Total manhours required for performing
all Major Operations and Events -   6,061

Total accumulated (consecutive) hours
required -   627

Total Orbital Checkout personnel required -   14

Total Mars Landing Vehicle Flight Crew -   8

E-1

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT, AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) OLSV Without Manipulators	OLSV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	PGSU	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	(7) Man-Hours Per Function	HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
1. Launch Life Support Section to Earth orbit (manned by limited checkout crew)	a. Launch to parking orbit. b. Separate and jettison fairing and launch escape propulsion. c. Transfer to assembly orbit. d. Separate payload and boost stage. e. Separate launch structure and adaptor. f. Activate payload stabilization system.	No orbital operations. Ground initiated and controlled.												OLSF would serve as a focal point for assembly and checkout operations. It would also contain the necessary checkout equipment, auxiliary vehs. and would house the necessary orbital checkout crew.	If no OLSF available as many as 8. orbital c/o crewmen could be launched with Life Support Section.	Time required to perform this operation is not charged to the time required for the orbital checkout crew to perform their functions.
2. Perform checkout of Life Support Section (LSS)	a. Reposition re-entry vehicle for entry into LSS.	a. Earth entry module detached from LSS by combination of automatic and manual operations. b. Pilot will maneuver Earth re-entry module (180° turn around) and join up with LSS. c. Module will be secured primarily by manual means.				X	X			5	1.0	1.0	5.0			Earth Entry Module
						X	X			2	.33	1.33	.66			From this configuration Extra-vehicular workers will be required. To this configuration
						X	X			4	1.0	2.33	4.0			
	b. Crew transfer to LSS	Internal transfer through hatch from one system to another by manual means.						X		8	.17	2.50	1.36			Life Support System may be pressurized from time of Earth launch.
	c. Deactivate required systems.	Manual switch activation.						X		1	.08	2.58	.08			
	d. Deactivate and/or remove non-essential pyrotechnics and store as req'd.	Extra-vehicular manual operations.					X			-	-	2.58	-			No additional time required; this and function c can be performed concurrently.

E-2

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) OSAV Without Manipulators / OSAV With Manipulators / Manipulators / Personnel Carrier / AMU / Auxiliary Equipment Assumed: Soft Suit and Extravehicular Tools/Equipment / Soft Suit and Intervehicular Tools/Equipment / RMU	(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs): Per Function / Total Accumulated	Man-Hours Per Function	(7) EFFECTS OF: HAVING OLSF / NOT HAVING OLSF	(8) REMARKS
	e. Activate all LSS and re-entry module systems and equipment in preparation for c/o.	Manual switch activation.	X	3	.17 / 2.75	.51		Examples of systems to be activated are ECS, electrical communications, stabilization, etc.
	f. Perform checkout of entire LSS including: o All subsystems o Two basic control stations o All self-contained, on-board automatic & manual checkout equipment. o All auxiliary equipment and instruments used by crew during mission.	By visual, manual, and automatic means. C/o crew will perform essentially same functions as described in Lunar Ferry Checkout Procedures. Appendix B.2.	X (several columns)	8	50.0 / 52.75	400.0	C/o crew would make use of OLSF and auxiliary c/o equipment as required. Note: If OLSF available, basic operation #3a would not be necessary	The LSS as described here contains all the essential subsystems of the crew vehicle except the propulsion stages (M-1, 2, 3, & M-4 stages) which are launched later, as discussed in Item 5. Since the Mars lander and the Lunar Vehicle appear at about the same time period, required c/o times and number of personnel for the latter have been used in computing requirement for this vehicle segment and its systems.
	g. Call Ground (GOSS) for next payload.	Voice communications		1	.08 / 52.83	.08	OLSF could perform this function.	Additions in time and personnel have been estimated based on the added functions as shown in column 2.
3a. Without OLSF launch orbital support assembly vehicle to Earth orbit (manned by additional checkout crewmen.)	a. } b. } Same as in c. } events 1a, b, d. } c, and d.	Basically ground initiated and controlled.			/ 52.83		With OLSF concept, orbital support assembly vehicle (OSAV) would be available from facility.	Since the payload is manned, on-board crew provides pilot capabilities in guidance, abort, etc. It is not deemed necessary to further define the crews role at this time.

E-3

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — OSAV Without Manipulators	OSAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intravehicular Tools/Equipment	IMU	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	Man-Hours Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
3b. With OLSF – Transfer Orbital Support Assembly Vehicle (OSAV) to LSS.	a. Transfer any additional checkout crewmen required from OLSF to OSAV.	OSAV hard docked to OLSF; crew transfers via pressurized passageway.	X							4	.17	53.00	.68			Crew would also transfer any tools needed. Minimum number of additional c/o crewmen needed is estimated to be (4).
	b. Separate OSAV from OLSF.	S.O.P. pilot functions. Second crewman would prepare hatch.	X							2	.17	53.17	.34			
	c. Transfer OSAV to LSS.	S.O.P. for piloting.	X							1	.50	53.67	.50			Time required for OSAV to translate from OLSF to LSS or from its arrival position in Earth orbit (when boosted from Earth) is assumed to be the same in both cases – 30 mins.
4. Rendezvous and dock OSAV with LSS.	a. Perform rendezvous maneuver.	S.O.P. for piloting.	X							1	.17	53.84	.17			
	b. Dock OSAV with LSS.	S.O.P. piloting techniques plus manual assistance from second crewman who secures hatch.	X							2	.17	54.01	.34			Both the LSS and the OSAV are pressurized.
	c. Checkout crew transfer from OSAV to LSS.	Manual transfer through pressurized hatch.	X							4	.25	54.26	1.00			Crew will also transfer any necessary hand tools.
	d. Confirm status of LSS and call for next payload.	Routine confirmation of operating status of LSS systems by visual and manual checkout.				X	X	X		4	.50	54.76	2.0	Checkout crew would contact OLSF, the latter being a central controller for orbital launch operations.		

B-4

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) OBAV Without Manipulators	OBAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RSU	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	Man-Hours Per Function	(7) HAVING CREW	NOT HAVING CREW	(8) REMARKS
5. Launch Crew Vehicle propulsion to Earth Orbit. (Propulsion system has 4 separate boost systems).	a.) b.) Same as events c.) 1a, b, c, d, d.)	Ground controlled.								-	-	54.76	-	OLSF would serve as focal point for assembly operations.		For purpose of this analysis it is assumed vehicle segments spares, equipment, fuel, etc., are available in Earth orbit at the time they are needed by the orbital checkout crew; thus, no added time is alotted for boosting such supplies into orbit.
6. Rendezvous and dock Life Support Section to Crew Vehicle.	a. Perform rendezvous maneuver.	Life Support Section (LSS) has propulsion unit which may be used for translating and otherwise positioning the entire unit.	X							2	1.0	55.76	2.0			Crew Vehicle with its 4 stages is stabilized in Earth orbit. It is maneuverable after Earth boost stage burn out.
	b. Align LSS to crew vehicle propulsion "vehicle".	S.O.P. piloting techniques for controlling and aligning LSS to stabilized crew vehicle.		X						3	.50	56.26	1.50			A minimum of one pilot and two observers are required.
		Pilot will be assisted by visual observers in effecting alignment function.														An OGAV may be needed.
	c. Dock LSS to Crew Vehicle.	Continuation and conclusion of task begun in event 6b.		X						3	1.0	57.26	3.0			
7. Assemble LSS to Crew Vehicle	a. Confirm alignment of electrical and fluid connectors.	Visual observations and manual operations.				X	X	X		10	30.0	87.26	30.00	Facility would serve as a storage place for spare parts, tools, test equipment, etc.		It is noted that the boost propulsion systems are not checked out during this operation.
	b. Complete assembly operations. Secure mechanical connectors.	Crew will be required to work in non-pressurized environment until sections secured.														
	c. Install separation system at separation plane.															
	d. Confirm assembly operations complete.															
	e. Call for next payload	Voice communications								1	.08	87.34	.08			

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — Manipulators Without OSAV	Manipulators With OSAV	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intravehicular Tools/Equipment	Tools	(5) No. of Men Required in Orbit	(6) Time Req'd (hrs) Per Function	Accumulated Total	(7) Man-Hours Per Function	EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
8. Launch Service Vehicle "A" to Earth orbit.	a.) b.) Same as events c.) 1a, b, c.	Ground controlled.								-	-	87.34	-			
	d. Position vehicle in assembly orbit.	By remote control (from OLSF or OSAV) activation of reaction control jets on Ser. Vehicle "A".	X							3	1.0	88.34	3.0	OLSF would act as focal point. Internal observer would monitor Service Vehicle positioning.		Three crewmen will be required — one in OLSF to monitor and direct the operation, and two in an OSAV (pilot and observer operator).
	e. Separate payload and boost stage.	By remote control.	X							1	.17	88.51	.17			This function should be executed before vehicle reaches its final position in assembly orbit in order to dispense with expended boost stage.
9. Launch Service Vehicle "B" to Earth orbit.	a.) b.) Same as in c.) Operation 8. d.) e.)	Same as in Operation 8.	X							2.7 avg.	1.17	89.68	3.17			Same as in Operation 8.
10. Checkout crew performs inspection of crew vehicle.	a. Activate all vehicle checkout equipment. b. Perform checkout of all vehicle systems. c. Perform visual inspection of vehicle structure. d. Confirm status of vehicle. Establish spares requirements.	By visual, manual & automatic means following activation of all vehicle systems considerable simulation checkout of boost propulsion systems will be required.		X		X	X	X		X 12	20.0	109.68	240.0	If OLSF is available, c/o crew will utilize c/o equipment aboard OLSF (as required) as well as that carried permanently aboard the MARS Landing Mission Crew Vehicle.		Since all subsystems of this vehicle, except the boost propulsion systems (M-1, 2, 3, & M-4 stages), have been checked out recently, emphasis during this operation will be on checkout of the propulsion systems. However, they cannot be checked out completely until the refueling operation has been completed (See Basic Operation No. 29).

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(5) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Manipulators Without OSAV	Manipulators With OSAV	Personnel Carrier	AMU	Soft Suit and Tools/Equipment Extravehicular	Soft Suit and Tools/Equipment Intravehicular	RCU	(3) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	Total Accumulated	(7) Man-Hours Per Function	Having OLSY	Not Having OLSY	(8) REMARKS
11. Checkout crew transfers to Service Vehicle "A".	a. C/o crew transfer to OSAV.	Transfer through hatch. Limited hand tools may also be transferred.	X							10	.17	109.85	1.70			Checkout personnel will be required to monitor, evaluate, operate, etc., those displays and controls at two control stations simultaneously - one in the re-entry module and the other in the mission module. OSAV is already hard docked to Crew Vehicle. Two c/o crewmen will remain in mission Crew Vehicle to operate c/o equipment. The Crew Vehicle and Service Vehicle "A" are separated by about 1,000 feet. A second crewman will be required to confirm hard dock joining operation although Service Vehicle "A" is not pressurized.
	b. Separate OSAV from Crew Vehicle.	S.O.P. pilot separation procedures. Second crewman will secure hatch.	X							2	.17	110.02	.34			
	c. Transfer via OSAV to Service Vehicle "A" and perform close-in rendezvous maneuver.	S.O.P. piloting procedures.	X							1	.25	110.27	.25			
	d. Dock OSAV to Service Vehicle "A".	S.O.P. pilot procedures for hard docking.	X							2	.17	110.44	.34			
	e. Crew transfer to Service Vehicle "A".	Crew transfer (2) at one time by entering hatch, securing door behind them, depressurizing hatch, opening outer door and entering Service Vehicle, followed by securing door in preparation for crewmen to follow.					X	X		10	.83	111.27	8.3			

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — OBAV Without Manipulators	OBAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	USD	(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	Total Accumulated	(7) Man-Hours Per Function	EFFECTS OF HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
12. Checkout crew performs checkout of Service Veh. "A".	a. Activate all vehicle systems.	By visual, manual, and automatic checking. Crew aboard Service Vehicle "A" will perform in a non-pressurized environment.	X			X	X	X		12	60.0	161.27	720.0	OLSF could contain any additional c/o equipment needed.		Service Vehicles "A" & "B" will not contain the ECS, food, storage and preparation systems, operator stations, sleeping quarters, etc., thus eliminating the need for such checkout tasks. However, both vehicles do contain additional equipment and systems to be checked such as auxiliary Mars landing vehicles, Mars exploratory equipment, scientific measuring devices, spares for all three vehicles, etc. Accordingly, the checkout times for either vehicle "A" or "B" are assumed to be the same as that for the Crew Vehicle.
	b. Perform c/o of vehicle systems.															
	c. Perform c/o of all auxiliary mission vehicles.	Checkout referred to here is of "operational" type, i.e. to determine if vehicle systems and auxiliary vehicles are functioning properly. C/o in depth will be conducted later.														
	d. Perform visual inspection of vehicle structure.															
	e. Same as 10d.															
13. Checkout crew transfers to Service Vehicle "B".	Same as in operation 11 (substitute vehicle "B" for "A").									10	1.59	172.86	10.93			Same as in Operation 12.
14. Checkout crew performs checkout of Service Veh. "B".	Same as in Item 12. Note: Add as the last function: Calls for support vehicle.		X			X	X	X		12	60.0	232.86	720.0	Same as in Operation 12.		Same as in Operation 1.
15a. Without OLSF Launch Orbital Support Assembly Vehicle. (OSAV)	Same as events 1a, b, c.	Ground controlled.								-	-	232.86	-			
15b. With OLSF transfer OSAV for resupply.	Transfer OSAV from Service Veh. "B" to OLSF for resupply.	S.O.P. piloting techniques.	X							2	.67	233.53	1.34	Will serve as storage area for supplies.		Time is included for separating from Service Vehicle "B" and translating to OLSF.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	(6) Accumulated Total	(7) Man-Hours Per Function	(7) Effects of HAVING OLSF	(7) Effects of NOT HAVING OLSF	(8) REMARKS
			Manipulators OSAV Without	Manipulators OSAV With	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	PGA							
	b. Rendezvous & dock OSAV with OLSF.	S.O.P. piloting techniques. Second crewman will prepare and "seal" hatch.	X							2	.33	233.88	.66			
	c. Load supplies for mission vehicles from OLSF to OSAV.	By manual means. Both systems are pressurized for shirt sleeve environment operation.								4	1.50	235.38	6.00			Hatch open affording no obstruction in passageway between the two systems. The two systems are pressurized.
	d. Transfer OSAV from OLSF to Service Vehicle "B".	Crewman will secure hatch. Pilot will separate systems, then translate to vehicle "B".	X							2	.67	236.05	1.34			Time includes hatch preparation and translation time.
16. Rendezvous and dock OSAV with Service Vehicle "B".	a. Preform rendezvous maneuver.	Rendezvous and dock by extention of S.O.P.	X					X		3	1.33	237.38	3.99			Service Vehicle "B" not pressurized. Crew must work in pressure suits.
	b. Dock vehicle.															
	c. Unload supplies.	Manually unload supplies.														
17. Refurbish and repair Service Veh. "B"	a. Perform repair functions on Service Vehicle.	Will depend upon repairs to be performed.				X	X	X	X	8	10.0	247.36	80.0			Repair functions to be performed are unknown. The time shown is an amount set aside for contingencies.
	b. Refurbish expendable systems of Service Vehicle.	This may involve connecting of many servicing lines from OSAV to vehicle.				X	X	X		8	10.0	257.36	80.0			Time required is difficult to estimate as refurbishing operations will depend upon the amount and type of supplies to be supplied the vehicle.
	c. Re-establish spares level in Service Vehicle.	Inventory.					X	X		8	5.0	262.36	40.0			

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(4) Auxiliary Equipment Assumed — Manipulators Without OBAV	Manipulators With OBAV	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RGU	(5) HOW FUNCTION PERFORMED (Man/Machine Interaction)	No. of Men Req'd in Orbit	(6) Time Req'd (Hrs) Per Function	Accumulated Total	(7) Man-Hours Per Function	Effects of HAVING OLAV	NOT HAVING OLAV	(8) REMARKS
18. Recheck Service Vehicle "B".	a. Perform checkout of Service Vehicle "B".				X	X	X		By visual, manual and automatic means. See Operation 12.	12	10.0	272.36	120.0			This operation is a verification of the operating status of all vehicle subsystems following the more thorough checkout conducted under Operation 13.
	b. Confirm status of vehicle.															
19. Orbital support port assembly vehicle(s) transfer to Service Vehicle "A".	a. Separate support vehicle(s) from Service Vehicle "B".	X							Crewman will secure pressure hatch; pilot will then execute separation maneuver.	2	.17	272.53	.34			
	b. Transfer and service vehicle "A" and perform close-in rendezvous.	X							S.O.P. for piloting.	1	.25	272.78	.25			It is assumed that one support vehicle will suffice for delivering supplies.
	c. Dock support vehicle to Service Vehicle "A".	X							S.O.P. piloting techniques for hard docking.	2	.17	272.95	.34			
	d. Transfer logistics requirements to Service Vehicle "A".				X	X	X		Supplies will be manually transferred through non-pressurized hatch from one vehicle to the other.	4	1.33	274.28	5.32			Service Vehicle "A" is not pressurized. Crew must work in pressurized suits.
20. Refurbish & repair Service Vehicle "A".	All functions essentially same as in Operation 17 above.				X	X	X	X	Same as in Operation 17.	8	25.0	299.28	200.0			See remarks under Operation 18.
21. Recheck Service Vehicle "A".	All functions essentially same as in Operation 18 above.				X	X	X		Same as in Operation 18.	12	10	309.28	120.0			See remarks under Operation 18.
22. Orbital support vehicle transfer to Crew Vehicle.	All functions essentially same as in Operation 19.	X					X		Same as in Operation 19.	3.3 avg.	1.92	311.20	6.25			See remarks under Operation 19.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs)			(7) EFFECTS OF		(8) REMARKS
			Manipulators OSAV Without	Manipulators OSAV With	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	MSU		Per Function	Accumulated Total	Man-Hours Per Function	HAVING OLSF	NOT HAVING OLSF	
23. Refurbish & repair Crew Vehicle	All functions essentially same as in Operation 17 with deletion of event 17c.	Same as in Operation 17, less "Inventory" requirement.	X			X	X	X	X	8	25.0	336.20	200.0			Total time required to perform this operation has been estimated same as Operation 17. Even though time will not be required for re-establishing spares level (Event 17e) additional time will be required for servicing the Life Support System.
24. Recheck Crew Vehicle.	a. Perform checkout of Crew Vehicle. b. Confirm status of mission vehicle, establish status of convoy vehicles for integrated test (See Operation 25).	By visual, manual, & automatic means. Most of the checkout to be performed is done utilizing the checkout equipment aboard the Crew Vehicle as this vehicle is basically self-sufficient.				X	X	X	X	12	10	346.20	120			
25. Conduct convoy integration tests.	a. Activate command control systems for convoy vehicles.	By manual switch activation from control "stations" aboard the mission crew veh.								4	1.0	347.20	4.0	OLSF would co-ordinate such activity.		
	b. Perform "INTEGRATED" checkout of all three convoy vehicles.	By activation of remote controls from mission Crew Vehicle Subsystems and equipment in vehicles "A" and "B" will be activated and their performance evaluated.	X			X	X	X	X	12	10	357.20	120.0			In particular, guidance and navigation systems, including remote control signaling, will be evaluated for proper functioning. The nuclear boost propulsion systems cannot be activated but by other means must be checked to the maximum degree possible.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) OGAV Without Manipulators	OGAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	ROU	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	Man-Hours Per Function	(7) SAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	c. Perform simulated countdown and launch.	C/D procedures consist primarily of confidence checks performed by the checkout crew. Checks consist of visual and automatic checks (preprogrammed) of vehicle subsystems in addition to observations of flight parameter displays as the simulated launch time approaches.								12	6.0	363.20	72.0	OLSF would control entire operation.		Boost propulsion systems will not be fired.
	d. Deactivate non-essential systems.	Operation of manual controls and observation of displays.														
	e. Confirm status of mission vehicles for maintenance and surveillance period.	Such vehicle status will largely result from Events 25 b and c above.				X	X		X	4	.25	363.45	1.00			No additional time required. This task performed concurrently with Events 25 b and c.
	f. Perform tests of spin extension.	By manual operation of appropriate internal controls								–	–	363.45	–			No additional time required. This operation will have been completed during basic operation #10, and will have been verified again (as required) during basic operation #25.
	g. Perform separation and assembly operations required to configure Earth re-entry module mission capture configuration. This involves both Earth re-entry module and the M-4 stage propulsion unit. Return vehicle to normal configuration.	This operation, to be executed primarily by manual means, will require established Standard Operating Procedures (S.O.P.) since the flight crew will be required to so configure the mission vehicle before re-entering the Earth's atmosphere.				X	X		X	6	30.0	393.45	180.0			This operation will be a "dry run" to ascertain that the several modules and propulsion stages can be properly fitted and secured.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs)			(7) EFFECTS OF		(8) REMARKS
			Manipulators OSAV Without	Manipulators OSAV With	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	ROU		Per Function	Accumulated Total	Man-Hours Per Function	HAVING OLSF	NOT HAVING OLSF	
26. Conduct maintenance & surveillance of convoy vehicles; establish routine crew duty cycles for maintenance and surveillance of vehicles.	Without OLSF. Establish routine crew duty cycles for maintenance and surveillance of vehicles.	Manpower scheduling and planning.	X							-	-	393.45	-			No additional time required.
	b. With OLSF. Transfer support vehicle from Crew Vehicle to OLSF. (Contains checkout personnel in excess of flight crew level.) Return vehicle and personnel before next Earth launch.	SOP piloting procedures.								2	.67	394.12	1.34			
	c. Monitor status of vehicle system. Maintain vehicle attitudes, separation and orbital altitude.									-	-		-			No time or personnel allotted for this operation as its necessity will depend upon the availability of the next payload upon completion of Operation #25.
	d. Confirm status of vehicle acceptable for next payload.									-	-	394.12	-			
27. Launch Propellant Tanker Module #1 to Earth orbit.	a. Launch to parking orbit.	All functions ground controlled.								-	-	394.12	-	OLSF would act as central coordinator and as a center for orbital launch operations.		No additional time required. For the purpose of this analysis, it is assumed that with proper programming, this module could be made available in Earth orbit to the orbital checkout crew when needed.
	b. Separate and jettison launch fairing.															
	c. Transfer to assembly orbit.															

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Required	(5) No. of Men Required in Orbit	(6) Per Function	(6) Total Accumulated	(6) Man-Hours Per Function	(7) EFFECTS OF HAVING OLSS	(7) NOT HAVING OLSS	(d) REMARKS
28. Rendezvous and dock Propellant Tanker #1 with Crew Vehicle.	a. Remove service cover from propellant servicing area.	By extra-vehicular, manual operations.	O&V With Manipulators (X), PMU (X), Extravehicular Soft Suit and Tools/Equipment (X)	2	.25	394.37	.50			
	b. Perform rendezvous maneuver.	Tanker will have trans-stage which can be remotely controlled (from aboard crew or service vehicle) by visual and/or electronic observation means, tanker can be brought into close proximity of vehicle to be serviced.		2	.50	394.87	1.0			A detached observer, strategically located in an OSAV, may be required to assist in the close-in rendezvous phase. An orbital support assembly vehicle with manipulators may be required to assist in this function
	c. Align propellant tanker with Crew Vehicle.	This is a continuation of the maneuver begun in Event 28b.	O&V With Manipulators (X), PMU (X), Extravehicular Soft Suit and Tools/Equipment (X)	3	.25	395.12	.75			
	d. Dock propellant tanker to Crew Vehicle.	A combination of techniques may be employed such as: o Activation of reaction control system on propellant tanker by remote means. o Use of an orbital support assembly vehicle to assist in positioning the tanker. o Activation of Crew Vehicle reaction system, thus positioning the vehicle. o Assistance of extra-vehicular workers in aligning positioning and in particular, in securing the two systems.	O&V With Manipulators (X), PMU (X), Extravehicular Soft Suit and Tools/Equipment (X)	6	1.0	396.12	6.0			Additional extra-vehicular observers may be needed.
	e. Confirm alignment of propellant tanker lines.	By extra-vehicular observers.	PMU (X), Extravehicular Soft Suit and Tools/Equipment (X)	-	-	396.12				
	f. Confirm Crew Vehicle ready for propellant loading.	By visual and manual inspection functions.	PMU (X), Extravehicular Soft Suit and Tools/Equipment (X)	6	.33	396.45	1.98			Continuation of task begun in Event 28d.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(5) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(3) No. of M-B Required in Orbit	(6) Time Req'd (Hrs) Per Function	(6) Time Req'd (Hrs) Accumulated Total	(7) Man-Hours Per Function	EFFECTS OF HAVING OLSO	NOT HAVING OLSO	(9) REMARKS
			OSAV Without Manipulators	OSAV with Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	EMU							
29. Conduct propellant transfer to Crew Vehicle.	a. Perform propellant transfer operation.	S.O.P. pilot control action with simultaneous operation of controls for initiating fuel transfer.				X			X	5	.25	396.70	1.25			When refueling a vehicle by tanker-fuel transfer method, in lieu of assembly technique, the joined tanker and vehicle will have to be accelerated as a unit. Extra-vehicular observers will be required.
	b. Observe entire operation for leaks, for proper venting, etc.	Monitor propellant servicing area for leakage by (1) direct visual means, (2) observation of related gauges, and displays and, (3) by observation using remotely located t.v. cameras (if required).														
	c. Complete and terminate fuel transfer operation. Confirm propellant quantity in Crew Vehicle propulsion stages.	Simultaneous monitoring of gauges and operation of "shut-off" valves.								-	-	396.70	-			Continuation of Events 29a and b.
	d. Establish and/or confirm relative position of mission Crew Vehicle in convoy.	By S.O.P. pilot action. May be assisted by at least one observer.								2	.17	396.87	.34			
	e. Separate propellant servicing lines.	Propellant lines may require separation by manual means; extra-vehicular operation.				X	X			4	.50	397.37	2.0			
	f. Install covers at propellant servicing areas.	Manual means.				X	X			-	-	397.37	-			
	g. Confirm vehicle ready for separation of propellant tanker (separate tanker)	This task will require both extra-vehicular operations and observation and control action on the part of a orbital support assembly vehicle operator.		X		X	X			5	.33	397.70	1.65			Continuation of Task 29e.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(5) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed	(3) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	(6) Total Accumulated	(7) Man-Hours Per Function	EFFECTS OF — HAVING OLSP	NOT HAVING OLSP	(8) REMARKS
30. Transfer support vehicle (with checkout crew) and Propellant Tanker #1 to Service Vehicle "A".	a. Separate propellant tanker from Crew Vehicle.	Continuation of action begun in Event 29g.	Manipulators OSAV With (X); Extravehicular Soft Suit and Tools/Equipment (X); AMU (X)	5	.17	397.87	.85			
	b. Perform inspection of Crew Vehicle structure. Confirm status due to propellant tanker separation.	See Event 30a above.	Extravehicular Soft Suit and Tools/Equipment (X); AMU (X)	-	-	397.87	-			No additional time required. This is continuation of Event 30a.
	c. Transfer support vehicle and propellant tanker #1 from Crew Vehicle to Service Vehicle "A".	Propellant Tanker #1 moved by its own propulsion system. Commanded remotely by personnel on support vehicles S.O.P. piloting functions.	Manipulators OSAV With (X)	1	.25	398.12	.25			More than one (1) orbital support assembly vehicle may be required. A minimum of one is shown.
	d. Perform vendezvous with Service Vehicle "A".	S.O.P. piloting techniques with assistance of observer(s).	Manipulators OSAV With (X); Extravehicular Soft Suit and Tools/Equipment (X); AMU (X)	2	.25	398.37	.50			
	e. Align propellant tanker #1 with service module.	Same as in Events 29 c, d, e, f.								
	f. Dock propellant tanker #1 to Service Vehicle.									
	g. Confirm alignment of propellant servicing lines.									
	h. Confirm service vehicle ready for propellant loading.		Manipulators OSAV With (X); Extravehicular Soft Suit and Tools/Equipment (X X); AMU (X)	5.5 / 1.58 avg.		399.95	8.73			

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of M n Required in Orbit	(6) Per Function	(6) Accumulated Total	(6) Man-Hours Per Function	(7) HAVING OLSF	(7) NOT HAVING OLSF	(8) REMARKS
			OR&V Without Manipulators	OR&V with Manipulators	Personnel Carrier	UMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RMU							
31. Conduct propellant transfer to M-2 stage of Service Vehicle "A".	a. b. c. d. e. f. g. Same as in Events 29a thru g.	Same as in Events 29a thru g.								4.1	1.25	401.20	5.24			
	h. Confirm vehicle ready for Propellant Tanker #2.	Routine inspection and verification of vehicle status.								-	-	401.20				Continuation of Event 31g.
32. Separate and eject empty Propellant Tanker #1.	a. Separate Propellant Tanker #1 from Service Vehicle "A".	Extra-vehicular manual operations will be required. Empty tanker will then be moved out of immediate vicinity of the three mission vehicles.		X		X	X			4	1.0	402.20	4.0			It may prove desirable to "de-orbit" the empty tanker to preclude any possibility of future collision. (Remote firing of attached retro-rocket may be employed for de-orbit purposes.)
	b. Position empty tanker away from convoy, and eject out of respective area to prevent inadvertent collision.															
33. Launch Propellant Tanker #2 to Earth orbit.	Same as in Operation 27.	All functions ground controlled.								-		402.20				Same remarks as in Operation 27.
34. Rendezvous and dock propellant tanker #2 with Service Vehicle "A".	Same as Events 28b thru f	Same as in Operation 28.		X		X	X			4.2 avg.	2.08	404.28	8.83			
35. Conduct propellant transfer to M-3 stage of Service Vehicle "A".	All functions same as shown under Operation #29.	Same as in Operation 29.		X		X	X			4.1 avg.	1.25	405.53	5.24			

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	(6) Accumulated Total	(7) Man-Hours Per Function	(7) EFFECTS OF HAVING OLSF	(7) NOT HAVING OLSF	(8) REMARKS
			Manipulators without OBAV	Manipulators with OBAV	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RMU							
36. Transfer support vehicle (with crew) and propellent tanker #2 to Service Vehicle "B"	All functions same as shown under Operation #30. NOTE: Vehicle being serviced is vehicle "B" and its service module.	Same as Operation 30.		X		X	X			4.6 avg.	2.25	407.78	10.33			
37. Conduct propellent transfer to Service Vehicle "B".	a.) b.) c.) All functions same as shown d.) under Operation e.) 29. f.) NOTE: Vehicle g.) being serviced is vehicle "B".	Same as in Operation 29.		X		X	X			4.1 avg.	1.25	409.03	5.24			
	h. Establish refurbishment requirements for convoy vehicle systems to bring systems to mission readiness condition.	Through visual observation and by inventory for certain supplies (e.g., food, water, expendable personal items, etc.)				X	X	X	X	6	1.0	140.03	6.0			Type and amount of supplies needed will depend upon such factors as time since last refurbishment and extent of use of vehicles during the interim period; any inadvertent damage to vehicle requiring additional supplies; "natural" losses, etc.
38. Separate and eject tanker module.	Same as shown in Operation 32.	Same as shown in Operation 32.				X	X			4	1.0	411.03	4.0			Same remarks as in Operation 32.
39a. Without OLSF Launch support vehicle to Earth orbit.	Same as in Operation 27.	All ground controlled.								-	-	411.03	-			Same remarks as in Operation 27.
39b. With OLSF Transfer support vehicle from service vehicle to OLSF for resupply.	All functions same as shown in Event 15b.	See Event 15b above.	X							3.0 avg.	3.17	414.20	9.34			See remarks under Event 15b.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Manipulators Without OSAV	Manipulators With OSAV	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	HSM	(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	Accumulated Total	(7) Man-Hours Per Function	(7) EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
40. Rendezvous & dock support (refurbishment) vehicle with Service Vehicle "B"	All functions same as shown in Operation 16.	See Operation 16 above.	X			X		X	X	3	1.33	415.53	3.99			See remarks under Operation 16.
41. Service Vehicle "B" repair and refurbishment.	All functions same as in Operation 17.	See Operation 17. NOTE: Whereas the functions and their method of accomplishment are essentially the same as in Operation 17, it is anticipated that this operation can be accomplished in less time.	X			X	X	X	X	8	20.0	435.53	160.0			See remarks in Operation 17. The extent of repair, servicing and refurbishment operations will depend upon elapsed time since last such operation, the extent to which the vehicle's subsystems have been used, etc.
42. Conduct checkout of Service Vehicle "B".	a. Perform complete checkout of Service Vehicle Systems. b. Perform complete checkout of all auxiliary mission vehicles. c. Confirm status of Service Vehicle.	All functions and their manner of execution essentially the same as in Operation 12 above. It is anticipated this operation can be carried out in less time than Operation 12.	X			X	X	X	X	12	40.0	475.53	480.0	See Operation 12.		See remarks in Operation 12.
43. Support vehicle(s) transfer to Service Vehicle "A".	All functions same as in Operation 19 above.	See Operation 19.	X					X	X	3.3	1.92	477.45	6.25			
44. Service Vehicle "A" repair and refurbishment.	Same as in Operation 17.	Same as in Operation 17 with one difference - it has been estimated this operation can be accomplished in 20 hours as opposed to 25 (as shown for #17).	X			X	X	X	X	8	20.0	497.45	160.0	See Operation 12.		See Operations 17 and 41.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(5) No. of Men Required in Orbit	(6) Time Req'd (Hrs)			(7) EFFECTS OF		(8) REMARKS
			OSAV Without Manipulators	OSAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Tools/Equipment Extravehicular	Soft Suit and Tools/Equipment Intervehicular	MMU		Per Function	Accumulated Total	Man-Hours Per Function	HAVING OLSF	NOT HAVING OLSF	
45. Conduct checkout of Service Vehicle "A"	Same as in Operation 42.	Refer to Operations 12 and 42 for additional information.	X			X	X	X	X	12	40.0	537.45	480.0			
46. Support vehicle(s) transfer to Crew Vehicle.	Same as in Operation 19.	See Operation 19.	X					X	X	3.3	1.92	539.37	6.25			
47. Crew Vehicle repair and refurbishment	Same as in Operation 17 with deletion of Event 17c.	See Operation 17.														See Operation 17.
48. Conduct checkout of Crew and Service Vehicles.	Function which must be performed in support of this operation are those listed under Events 24a, b, and 25a thru d (only).	See Operations 24 and 25.	X			X	X	X	X	8	20.0	559.37	160.0			NOTE: Whereas number of personnel shown is an average of 11 a minimum total of 12 is required for performing certain functions falling under this operation.
	Add: confirm status of vehicles and call for mission crew.		X			X	X	X	X	11 avg	27.25	586.62	317.0			
49a. Without OLSF Launch Mission Crew Carrier to Earth orbit.	Same as shown in Operation 27.	See Operation 27.	X							-	-	586.62	-			Since carrier is manned, the on board crew will be required to carry out a number of control and emergency functions.
49b. With OLSF Transfer mission crew to Crew Vehicle.	a. Separate support vehicle from Crew Vehicle.	SOP pilot functions.								1	.17	586.79	.17			A portion of the orbital checkout crew can be transferred to the OLSF. The remaining personnel can be transferred during Event 50d.
	b. Translate to OLSF									1	.50	587.29	.50			
	c. Transfer part of checkout crew from support vehicle to OLSF and transfer mission crew from OLSF to support vehicle.	By manual passage through pressurized hatch.	X					X		5 avg.	.33	587.62	1.65			

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	OSAV Without Manipulators	OSAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RMU	(5) No. of Men Required in Orbit	(6) Per Function	Accumulated Total	Man-Hours Per Function	(7) HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	d. Detach support vehicle from OLSF and transfer mission crew to Crew Vehicle.	SOP piloting techniques.	X							2	.50	588.12	1.00			
50. Rendezvous and dock with Crew Vehicle.	a. Events 50 a & b same as Events 16 a & b.	See Operation 16.	X							2	.33	588.45	.66			
	c. Transfer mission crew to LSS of Crew Vehicle.	By transfer through pressurized hatch (both vehicles pressurized.								8	.17	588.62	1.36			
	d. Transfer remaining orbital checkout crew to support vehicle.	Same as in Event 50c above.	X							5	.17	588.79	.85			
51. Support vehicle transfer to parking orbit.	a. Separate support vehicle from LSS of Crew Vehicle.	SOP pilot separation maneuver with second crewman securing hatch.	X							2	.17	588.96	.34			
	b. Transfer to parking orbit. (Orbit must be compatible for providing television coverage during launch of the convoy vehicles.)	SOP piloting functions.	X							1	.50	589.46	.50			This vehicle will require a minimum of two (2) crewmen to monitor the launch and to stand-by to render assistance in case of emergency.
52. Mission crew conduct mission readiness test.	a. Activate convoy vehicle systems.	See Event 25a.								8	.33	589.79	2.64			This operation consists of activating all necessary vehicle systems and completion of the warm-up period.
	b. Perform mission vehicle checkout; confirm status.	This function amounts to pre-flight operations of a minimal nature, primarily by observation of vehicle displays and indicating devices.					X	X	X	8	6.0	595.79	48.0			This operation is considered similar to pre-flight type of evaluation by the mission crew.

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(5) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed							(3) No. of Men Required in Orbit	(6) Time Req'd (Hrs) Per Function	(6) Time Req'd (Hrs) Total Accumulated	(7) Man-Hours Per Function	(7) EFFECTS OF — HAVING OLSF	(7) EFFECTS OF — NOT HAVING OLSF	(8) REMARKS
			Manipulators Without OSAV	Manipulators With OSAV	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intervehicular Tools/Equipment	RGU							
	c. Perform simulated countdown & launch.	Simulated countdown and launch function will be pre-programmed and taped to facilitate their automatic execution. Crew will function primarily as initiators of specific, applicable programs and evaluators of results.								12	6.0	601.79	72.0	OLSF will serve as central control for executing this function.		A minimum of 4 crewmen will be needed in the OLSF to carry out the simulated countdown operation in addition to the 8 flight crew members aboard the Crew Vehicle.
	d. Confirm ephemeris data and vehicle attitude for launch.	By voice and data communications with ground and/or OLSF. Visual readouts from vehicles instruments and displays will also be necessary.								3	.33	602.12	.99			
	e. Confirm vehicle ready for countdown.	Flight crew will summarize results of pre-flight, simulated countdown and launch, and vehicle launch attitude evaluation and confirm to OLSF and to ground that convoy is ready for countdown.				X	X	X	X	12	.50	602.62	6.00	OLSF crew will assist as required in this operation.		
53. Conduct pre-launch operations and countdown.	a. Initiate pre-launch activities.	Maintain vehicle systems and equipment "ON" (from Operation #52). Notify ground and OLSF ready for pre-launch operations.								1	.08	602.70	.08			Vehicle commander will notify ground and OLSF. NOTE: This prelaunch checkout is essentially composed of energizing all vehicle systems simultaneously and performing the checkout function.
	b. Verify status of vehicle systems.	This is continuation or re-verification of Operation 52e.										602.70				This operation was essentially completed in #52 above.

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FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed — Manipulators Without OSAV	OSAV With Manipulators	Personnel Carrier	AMU	Soft Suit and Extravehicular Tools/Equipment	Soft Suit and Intravehicular Tools/Equipment	PSU	(5) No. of Men Required in Orbit	(6) Time Req'd (Hr.) Per Function	Accumulated Total	Man-Hours Per Function	(7) EFFECTS OF — HAVING OLSF	NOT HAVING OLSF	(8) REMARKS
	c. Initiate and complete pre-launch checkout.	Each vehicle subsystem will be automatically programmed. Except (possibly) for the M-1 (Earth escape) stage, the flight crew must be capable of conducting the pre-launch checkout operation, as they will be required to do so at other times during the mission when no other facilities are available.				X	X	X	X	12	12	614.70	144.0	Emphasis on OLSF checkout role will be in evaluation of M-1 (Earth escape) propulsion systems of each vehicle and in overall evaluation of the entire pre-launch checkout phase.		Consult Checkout and Countdown Procedures for the Lunar Ferry Appendix B.2 for crew tasks and orbital procedures similar to those required for this operation.
	d. Confirm vehicle status and establish all systems ready for final countdown.	Continuation of functions initiated above.								-	-	614.70	-			
	e. All mission flight crew members enter Earth re-entry module in preparation for orbital launch.	By manual passage through air lock.								6	.33	615.03	1.98			At least two crewmen were stationed in the re-entry module in support of the checkout function being performed.
	f. Re-position re-entry module for launch from Earth orbit.	SOP pilot control functions assisted by other crew members as needed.								4	.33	615.36	1.32	Assistance will be required from OLSF for verification.		Number of personnel required to perform this function has been estimated as 2 in mission vehicle (pilot and one other) plus 2 from the OLSF.
54. Initiate final countdown.	a. Initiate countdown b. Complete all countdown up to automatic sequence portion. c. Initiate countdown "hold"-synchronize launch time with automatic launch count.	Consult Checkout and Countdown Procedures for the Lunar Ferry, Appendix B.2 for example of types of crew activities.								12	10	625.36	120.0	OLSF will control countdown and will assist the flight crew as required.		Countdown procedures consist primarily of confidence checks performed by the flight crew & are a repetition of checks performed during the pre-launch checkout. Countdown checks consist primarily of visual & auto. checks of veh. subsystems & equip. in addition to observation of flight parameter displays as the launch time approaches.

FUNCTION AND TASK ANALYSIS

RE: ASSEMBLY, REFURBISHING, CHECKOUT AND COUNTDOWN OF MARS LANDING VEHICLE

(1) MAJOR OPERATION REQUIRED	(2) EVENT (FUNCTION)	(3) HOW FUNCTION PERFORMED (Man/Machine Interaction)	(4) Auxiliary Equipment Assumed	(5) No. of Men Required in Orbit	(6) Time Req'd (hrs) Per Function	(6) Accumulated Total	(7) Man-Hours Per Function	(7) EFFECTS OF — HAVING OLSF	(7) NOT HAVING OLSF	(8) REMARKS
	d. Initiate automatic countdown sequence	This will occur during the automatic count.		1	-	625.36	-			An "outside" observer may be necessary.
	e. Confirm relative position of other vehicles in convoy.	Visual observation of appropriate displays, assisted by direct visual observations where possible.		2	.17	625.53	.34	Crew vehicle will report to OLSF; the latter will report to ground.		
	f. Confirm relative position of other vehicles in orbit.	Continuation of task begun in Event 4e.		-	-	625.53	-			
55. Convoy launch	a. Initiate launch sequence.	Monitor and control functions. Crew will have capability of terminating launch at any time.		12	-	625.53	-			Launch will be automatic with flight crew in command. Amount of time unknown.
	b. Orbit launch of convoy.									Launch will be automatic with flight crew in command. Amount of time unknown.
	c. Orbital vehicles monitor launch and confirm injection.	Crews within orbital vehicles will monitor and report on entire operation. OLSF crew would also monitor the launch.		6	.17	625.70	1.02			The number of such vehicles required is unknown. However there may be as many as two, with each vehicle containing two crew members.
	d. Without OLSF support vehicles and mission crew carriers return to Earth. or With OLSF Support vehicles and mission crew carriers return to OLSF.	SOP pilot techniques for re-entry. / SOP pilot techniques for translating in space.		4 min.	.50	626.20	2.00			
			TOTAL			626.20	5060.58			

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